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ABSTRACT

This is the final report of the Physical Science for Nonscience Students (PSNS) development project. The report includes five major topics and five appendices. The first section, the History of Organizational Activities, discusses the conferences in 1963-64 that initiated the planning of the course. The remaining sections include Administration, Materials Development, The Role of the Advisory Board, and Special Projects. (SA)

PSNS

Physical Science for Nonscience Students

Final Report

January 1971

Rensselaer Polytechnic Institute

Troy, New York

ACKNOWLEDGMENTS

The production of this final report of the PSNS Project has been a labor of love. It has brought back fond memories of six or more years of cheerful and fruitful cooperation with the many members of the PSNS staff; with those dedicated trial teachers who persisted in spite of many difficulties and encouraged us to overcome initial problems and bring forth a finished product, the PSNS course; with the members of the Advisory Board for their patience and good sense in offering their advice; with our publisher, John Wiley and Sons, Inc. who crowned our efforts with a final text which is a credit to the bookmaker's art; with Damon Educational, Inc. who not only supplied humdrum experimental materials, but also designed and constructed ingenious and inexpensive devices to keep our experimental program simple but technically sound; with Professor Wayne W. Welch of the University of Minnesota, who, somewhat to our bewilderment, has carried us through a formal program of evaluation of the PSNS course; and last but not least with the National Science Foundation, not only for financial support, but also for patience and sound advice in solving our occasional administrative problems.

The undersigned has assembled and edited this report but he has written only a small portion of it. The major contributions, both in organization and actual writing, have been made by Professor A.A.Strassenburg, Chairman of the Advisory Board and Associate Director of PSNS, and by Dr. Elizabeth E. Wood, Associate Director and Chairman of the Advisory Board during the early years of the project. This is fitting and proper. In saying this, the Director is not rejecting responsibility for any errors in this document, but rather he is paying tribute to the two persons who have been the prime movers in the PSNS project from the time when it was only a vague idea to the present when it is a successful and continuing program. It has been a real privilege to work with both of them.

The editor edits and he feels very important, but the credit for the final appearance of a good manuscript belongs elsewhere. The undersigned gratefully acknowledges the invaluable services of his secretary of many years, Mrs. Frances Feski. She not only typed the manuscript, but with her years of experience she has many times eliminated the editor's errors, those of omission as well as those of commission.

The final appearance of the document as the reader sees it is a product of the printer's art. Here the credit goes to Mr. William J. Jones of the Fort Orange Press of Albany, N.Y. With his usual good sense and good humor, he has shepherded this document through the pitfalls of the printing and distribution of this report.

Lewis G. Bassett
Director, PSNS

Rensselaer Polytechnic Institute
Troy, N. Y.
January 1971

CONTENTS

A. HISTORY OF ORGANIZATIONAL ACTIVITIES

1. Organizational Conference, September, 1963

The Commission on College Physics (CCP) and the Advisory Council on College Chemistry (ACCC) often discussed during their early meetings the need for better college science courses for the preparation of elmentary school teachers. On Sep 5-7, 1963 these two organizations sponsored a conference in Chicago to explore the need for and interest in the development of materials for a laboratory-oriented physical science course which would be interesting and helpful to elementary education majors. Forty physics teachers, chemistry teachers, and representatives of state education departments from California, Florida, Illinois, New York, Pennsylvania, Texas, and Washington participated. Geographical grouping of invitees was employed in the hope that a group with enthusiasm and talent above threshold for the organization of a development project would initiate short-range interactions resulting in a successful proposal for support.

The conferees agreed that a new type of college-level physical science course should be developed. They also identified desirable objectives for such a course and enumerated the characteristics typical of the students who would enroll. Sufficient interest was exhibited by some conference participants to justify a discussion of appropriate organizational procedures and the identification of competent, available project staff. A report of this conference is included in Appendix A-1.

2. Follow-up Conference, October, 1963

The Chicago Conference generated considerable interest in the development of physical science course materials among scientists and educators in the North Atlantic region. To stimulate further efforts toward the organization of a course-development project, the Commission on College Physics, assisted by the Advisory Council on College Chemistry, held a meeting at their own offices in Rosemont, Pennsylvania on Oct 18-19, 1963. Invitations were sent to 26 individuals selected because of their insight and experience in teaching science to non-science majors or because of qualifications for specific roles it was hoped they would play in future activities. In addition to talented teachers and curriculum developers, the participant list included designers, film makers, and apparatus developers who contributed to an emphasis on the artistic presentation of science materials through the use of media and techniques not conventionally used for science instruction. Philip Morrison gave the keynote address, a talk which was later published under the title ''Less May Be More'' (reprint included in Appendix A-2).

An important result of this conference was the development of a feeling for the tone and style appropriate to a successful course for nonscience students. A more tangible accomplishment was the identification of Rensselaer Polytechnic Institute (RPI) as a suitable development site and Lewis Bassett, Professor of Chemistry at RPI, as a willing and able administrative director. A report of this conference is included as Appendix A-2.

3. Continuing Discussions, Winter, 1963-64

During the winter of 1963-64, discussions aimed at describing a desirable course continued. Contacts were made with prospective project staff members, and arrangements were made for providing the facilities and services which would be required by the materials developers. Preliminary drafts of a proposal requesting project support were also prepared. The principle participants in these activities were Lewis Bassett, Harold Faigenbaum, and Robert Resnick of RPI and Walter Michels, Edward Lambe, and Arnold Strassenburg of CCP.

Progress on the proposal proceeded slowly. It was difficult to secure commitments from an adequate number of creative scientists. There was insecurity concerning the possibility of ultimately obtaining a grant, and neither RPI nor CCP could sustain operations for long without one. Yet the concept of a good science course for elementary schools teachers was infectious and efforts continued. A major breakthrough occurred in April when Dr. Elizabeth Wood, then a crystallographer at Bell Telephone Laboratories, agreed to serve as leader of the materials development staff.

4. The Boulder Conference on Physics for Nonscience Majors, July, 1964

At the same time that discussions about a physical science course for prospective elementary school teachers were occurring, the Commission on College Physics was promoting a conference on physics courses for nonscience majors. While these two projects were originally designed to serve what were conceived to be somewhat different needs, the obvious relationship between them was apparent. The CCP staff physicists

felt that the proposed conference on physics courses would provide an excellent opportunity to prepare specifications for suitable physical science courses, and that the existence of course descriptions would assist the RPI group in their efforts to prepare a proposal for course development. Attention to physical science courses was therefore built into the plans for the conference.

The University of Colorado ultimately requested of and received from the National Science Foundation a grant which permitted them to host the conference Jul 20-29, 1964; Malcolm Correll of the Colorado Physics Department served as conference director. Physical science courses received attention in two ways. First, physical science courses taught during 1963-64 by Walter Knight at the University of California at Berkeley, by Melba Phillips at the University of Chicago, and by Edwin Uehling at the University of Washington were described in detail by the instructors and analyzed by the conference participants. Expanded course outlines, including records of daily events, of these and other courses were provided in advance to conference participants. Second, one of seven small discussion groups devoted its time for portions of six days to the production of outlines for several types of physical science courses. An early conception of the PSNS course was contributed by E. A. Wood in the form of a course outline complete with ''guiding principles'', ''useful techniques'', ''topics and some suggestions for their treatment'', and ''first-hand experiences'' to illustrate the phenomena to be studied. The enthusiastic acceptance of this course outline certainly gave confidence to the RPI group and

contributed to the ultimate adoption by the PSNS staff of many ideas which received their first thorough examination at Boulder. The relevant pages of The Proceedings of the Boulder Conference on Physics for Nonscience Majors are reproduced in this report as Appendix A-3.

5. The Birth of PSNS, September, 1964

Following a year of labor, the PSNS Project though, still unnamed, was born in a Howard Johnson Motor Lodge in Latham (near Troy) New York on Sep 9-11, 1964. Having by then established the general features of the course to be produced and having identified a sufficient number of interested and creative materials developers, the PSNS leaders met to prepare a final version of a proposal for project support. The CCP provided fund and staff assistance for this meeting.

Two groups developed and worked separately on essential elements of the proposal. One group continued earlier discussions concerning the content and level of the course. There were vigorous debates about the importance of slowing the pace and narrowing the scope ordinarily associated with elementary-level interdisciplinary science courses. RPI scientists played prominent roles in these discussions; these included Robert Resnick and Lawrence Katz of the physics department and chemists Stanley Bunce, B. Wunderlich, and Harold Faigenbaum. This group ultimately produced a detailed description of the proposed course in substantial agreement with the model which had evolved from the Chicago, Rosemont, and Boulder Conferences.

The second group specified mechanisms for implementing the course development plans. The sources of needed resources were identified and

a production schedule was adopted. The leadership roles to be played by Lewis Bassett, Elizabeth Wood, and Robert Sells were described and appropriate commitments were obtained.

The final result of these efforts, after some editorial work during September and October, was a completed proposal which was submitted to the National Science Foundation in November, 1964. A gran' was made by the Foundation to Rensselaer Polytechnic Institute in April, 1965.

B. ADMINISTRATION

As discussed in Section A of this report, Rensselaer Polytechnic Institute submitted a proposal to the National Science Foundation in November 1964 for the development of a course in Physical Science for Nonscience Students (PSNS). A copy of this proposal appears as Appendix B-1 of this report. The NSF awarded a grant (No. GE-8573) to the Institute in April 1965. In the interval between these two events, considerable thought was given by the leaders of PSNS to the overall organization of the proposed project. With the advice of NSF in the course of negotiations leading to the grant, it was decided that the administrative staff would consist of a Director, Professor Lewis G. Bassett of the Chemistry Department of RPI, who would be the principal administrative officer of the project, and two Associate Directors, Professor Robert L. Sells of the Physics Department of State University of New York College at Geneseo and Dr. Elizabeth A. Wood of the Bell Telephone Laboratories. Dr. Wood would be in charge of the substantive part of the project, that is, the development of the course itself including the procurement of staff and materials to implement the development and operation of the course.

In addition an Advisory Board of leaders in science education was organized, with Dr. Wood as Chairman, to advise and assist these officers in the discharge of their duties. A list of the persons who have served on the Advisory Board over the years and an account of the invaluable contributions they have made to the success of PSNS constitute Section D of this report. It should be mentioned and emphasized here that the members of the Board have served throughout

the life of the project without pay. Expenses incurred in attendance at meetings have been borne by the project, but no consulting fees, honorariums, or the like have been requested by or paid to these men and women in return for their advice.

The substantive part of the project, that is, the development and implementing of the course, and the operations of certain special projects such as evaluation and promotion, are discussed in detail in Sections C and E of this report.

This Section B is reserved for a discussion of the more important aspects of the many administrative details which are an inevitable part of a project of this magnitude. Particular attention will be given to the financial matters which include funding, type and magnitude of disbursements, and even the disposition of a small amount of income. There is also a brief discussion of the role of administration and the part played by the administering officer and institution in a project of this sort.

1. Financial Matters

a. Funding

The original proposal, submitted to NSF on Nov 5, 1964, proposed a termination date of Sep 30, 1966 and a budget providing for an expenditure of $249,435. During the course of negotiations over the next few months, this sum was increased to $281,060. Some of the increase was at the request of RPI and some resulted from suggestions by NSF. The steps in the provision of these funds and further extensions are listed below:

(1) NSF Grant .E-8573, Apr 11, 1965. Termination Sep 30, 1966. Sum provided by grant $128,110.

(2) Amendment No. 1, Nov 3, 1965. Sum provided - $152,950 (balance of the $281,060 above).

During the spring and summer of 1966, RPI proposed an extension of the termination date to Nov 30, 1968, and submitted a budget calling for an additional expenditure of $403,305.

(3) Amendment No. 2, Oct 19,1966. Termination extended to Nov 30, 1968. Sum provided - $250,000.

(4) Amendment No. 3, Jun 30, 1967. Sum provided - $153,305 (balance of $403,305 above).

Amendment No. 3 brought the total funding provided by NSF for PSNS to $684,365. No further funding has been requested or provided. The termination date has been extended a number of times without additional funds. This has been accomplished by negotiation by correspondence between the project Director and the incumbent Program Director of the Science Curriculum Improvement Program of NSF. No formal amendments have been necessary.

(5) Letter from NSF to the Director, May 16, 1968. Termination extended to Jun 30, 1969.

In the summer of 1968, RPI cut drastically the funds available to the project Director. This move was caused by the retrenchment program of NSF. The result was a severe delay in PSNS activities. The original funds were restored in January 1969 and an extension of the termination date was requested.

(6) Letter from NSF to the Director, Mar 20, 1969. Termination extended to Jun 30, 1970.

In the spring of 1970, it was obvious that the evaluation program and the workshop program could not be completed by Jun 30, 1970. Funds were still available, and a further extension was requested for the first semester of the academic year 1970-71.

(7) Letter NSF to the Director, Jun 16, 1970.
Termination extended to Jan 31, 1971.

It is anticipated that project activities will be completed at the end of January 1971, including this final report, and the project will terminate at that time.

No discussion of financial matters can be complete without an expression of appreciation for the patience and consideration displayed by the gentlemen who have occupied the position of Program Director of the NSF Science Curriculum Improvement Program over these six years. They have been our primary contact with NSF and we are grateful to them.

b. Disbursements

The above discussion on funding presents a definite total figure $684,365. One cannot be so definite at this point about disbursements. The total disbursements through October, 1970 are $652,035.59. This does not include bills outstanding as of Nov 1, and it does not include costs incurred during the last three months of the project Nov 1, 1970 - Jan 31, 1971. A final balance between funding and disbursements cannot be made until the books are closed after the termination of the project when RPI will report total disbursements in three categories: salaries, supplies and services, and overhead (15% of direct charges).

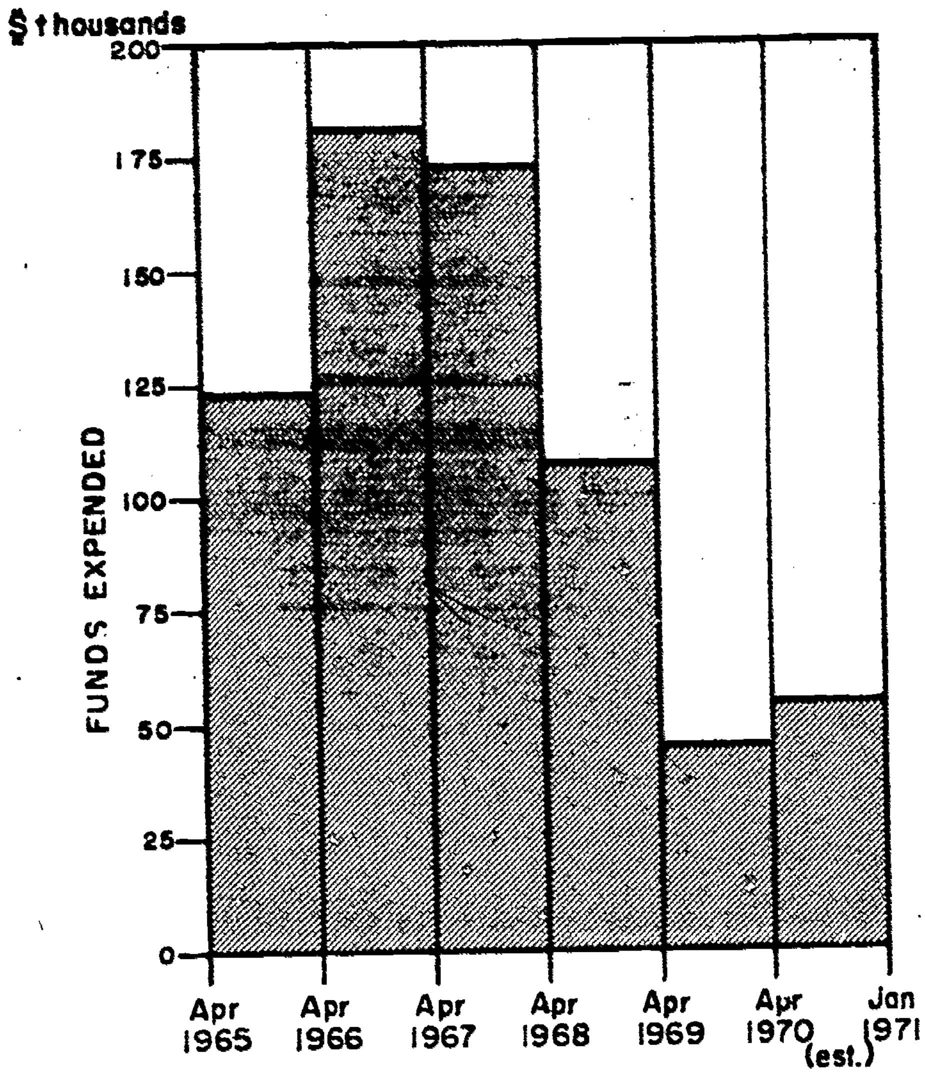


Figure B-1 Annual Expenditures of Funds

It is useful at this point, however, to consider the more important types of expenditures, those characteristic of the project, and to present an estimate of the totals anticipated for each type. Since we are accustomed to judge importance by dollars, we might expect that we would arrive at the relative importance of various aspects of the project by listing the cost of each. It is hoped that we can avoid this trap. Furthermore, in estimating type costs there may be some duplication. For instance, the cost of printing and distribution of test instruments for evaluation are included below in both disbursements for publication, and disbursements for evaluation. Keeping

these tfalls in mind let us consider estimates of some of the major types of disbursements:

(1) Salaries and Consulting Fees

These two methods of reimbursement are considered together because of the nature of the project. Since practically all of the professional staff in the summer sessions were teachers, they were each paid a summer salary on the bais of the time spent in Troy and the academic salary for the academic year following. (They were also provided living quarters by the project for themselves and their families.) Service personnel were paid at hourly rates set by RPI. When services of professional staff were required during the academic year, remuneration was made through a consulting fee of $75 per day. With NSF approval, a higher daily rate was paid for certain special services such as conducting a workshop session (see Section E) or supervising a comprehensive evaluation program.

Through Oct 31, 1970 the project has paid about $190,000 in salaries and $40,000 in consulting fees. Estimating additional expenditures for the last three months of the project, and adding 15% for overhead on these direct charges, we arrived at a figure of about $250,000, or about 37% of the total funding of the project.

(2) Publication (at Project Expense)

(a) At RPI

The five volumes of the First Preliminary Edition of the text AN APPROACH TO PHYSICAL SCIENCE were printed by Central

Duplication and distributed by the Mailing Room at RPI. The total costs were approximately $16,000 which were paid by the project.

(b) At Fort Orange Press (Albany, N.Y.)

The Second Preliminary Edition of the text was printed and distributed by the Fort Orange Press of Albany, N.Y. Students taking the course were charged a nominal sum of one dollar for each of the three volumes constituting the text. The remainder of the costs of this edition was paid by the project.

In addition to the second preliminary edition of the text, Fort Orange printed and distributed the following:

The First Preliminary Edition of the Teachers' Resource Book

Five Newsletters (see Appendix E-3)

Two test instruments for the Evaluation Program

The final report of the project.

Widespread distribution (from 1000-2000 copies) was made of each of the above. The total expenditures to Fort Orange Press (including the final report) are estimated to be about $44,000.

Total disbursements for publication are then estimated to be approximately $60,000, adding 15% overhead we obtain $69,000 or about 10% of the total funding.

(3) Publication by John Wiley and Sons, Inc.

(a) Procedure for Selection of a Publisher

In December 1966 we asked the American Textbook Publishers' Institute to announce to all textbook publishers a

briefing session at which the PSNS project directors would describe specifications for publication of course materials and invite proposals from the publishers. This session was held at the American Institute of Physics headquarters in New York on Jan 10, 1967. About twenty different publishing houses were represented; some sent more than one representative. Bassett, Wood, Sells, and Strassenburg each described briefly aspects of progress in materials development and outlined hopes for the final product. There followed a lengthy question period. Several other Advisory Board members were also present and assisted the directors to provide answers. A deadline on proposals one month later was announced; when several publishers complained, this was increased to six weeks.

Eventually eight complete proposals were received; several other publishers sent publicity, books, and notes indicating interest but requesting an extension. Board members were invited to assist in reviewing the proposals; help was received from Resnick, Holden, Holcomb, Werntz, Bassett, Wood, Sells, and Strassenburg. These individuals met on Mar 21-22 and, after much discussion, succeeded in sorting the proposals into two groups: (1) promising but not enough information to guarantee satisfaction, (2) insufficient evidence for thorough understanding of and sincere interest in the goals of the project. It was decided to invite the four publishers in category (1) for private discussions with the directors. These discussions, each lasting two hours, were held on Apr 4; Bassett,

Wood, Strassenburg, Resnick, and Holden represented PSNS. As a result of these discussions, it became clear that one publisher did not understand the goals of the project, and another did not appear interested in cooperating with the directors in matters which we felt needed special attention. The remaining two publishers, one new and small, one old and established, both made strong bids, and no immediate decision was rendered. The five Board members submitted mail ballots within three days and Wiley was awarded the contract.

Wiley and RPI signed a contract approved by NSF on Feb 29, 1968.

(b) Wiley Publications

Third Preliminary Edition of the text

Final Hard-cover Edition of the text

Final Edition of the Teachers' Resource Book

Supplementary Chapters (5) to the text

Equipment Catalogue (see (4) below)

PSNS personnel has assisted Wiley in the promotion of published materials. For example, Earl Carlyon and A.A. Strassenburg were invited to describe PSNS materials to the Wiley salesmen at their annual meeting on Sep 13-14, 1968 at Montauk, Long Island. Strassenburg discussed the philosophy of the course, the audience for whom the course is intended, and the unique features of the course. Carlyon described the apparatus and performed several demonstrations. It appeared that the idea of selling apparatus and books as a package appealed to the Wiley salesmen.

(c) Foreign Translations

With the approval of PSNS and NSF, Wiley has arranged for foreign translation and publication in Japanese and Spanish. Wiley has approved contracts with

Tokyo Kagaku Dozin Co., Ltd., Tokyo, Japan

Editorial Reverte, S.A., Barcelona, Spain

Furthermore, Wiley Eastern Private Limited, a subsidiary of Wiley, is arranging for the publication of an inexpensive, paperback edition of the text in cooperation with the U.S. Information Service and the Government of India as part of the joint Indian-American Textbook program.

Publication of both of these translations and the Indian book (in English) may be anticipated in 1971. Considerable use of the PSNS course in Japan, Spain, South America and India may be anticipated.

(d) Income

The contract with Wiley provides for royalty payments to RPI which holds the copyright on PSNS publications. Twice a year royalty payments are received from Wiley. RPI places these funds in a special account. At present there is about $13,000 in this account. By the termination of the project the sum may have increased to approximately $25,000, and it will continue to increase as long as publications are sold. According to the grant from NSF, these funds ''shall be used in ways approved or determined by the Director or Deputy Director of the Foundation.''

(4) Equipment Supply

In Section C there is a detailed discussion of the importance of experiment in the PSNS course. A problem in the development and operation of the course is the development and supply of adequate but simple experimental materials. In the summer session of 1965 and academic year 1965-66, this was indeed a major problem. Mr. Earl Carlyon and Dr. Wood took the lead in the attack on the problem. They located desirable equipment with various suppliers, arranged for purchase of quantities sufficient for the eight trial schools and for shipment to the trial teachers. The expenses for these operations were borne entirely by the project. This was a very unsatisfactory procedure. In January 1966 Dr. Wood and Mr. Carlyon arranged to meet with representatives of seven suppliers of educational scientific equipment at the American Institute of Physics meeting in New York. All suppliers were interested in supply,but only one, Damon Educational of Boston, Mass., showed an appreciation of and an interest in the design and construction of simple, inexpensive equipment for a course like PSNS. Messrs. Arthur M. Vash, Wesley G. Perry and Edward B. Lurier were particularly helpful. They visited RPI repeatedly during the summer of 1966 and strove to construct, and to procure equipment and to supply the 23 trial teachers of the 1966-67 academic year. There were problems and delays, but, through their efforts and cooperation with Mr. Carlyon, the situation was considerably better than in the previous year. The expenses of these operations were borne

entirely by the project; teachers and students were supplied equipment gratis. The cost of these operations to the project totaled about $54,000.

By the opening of academic year 1967-68, Damon was prepared to take over the whole equipment program, still with the cooperation and assistance of the PSNS liaison man, Mr. Carlyon. At this point PSNS stopped subsidizing; teachers ordered their supplies from Damon and their institutions paid the bills submitted by Damon.

By the academic year 1968-69, there was a further change. One of the reasons for selecting Wiley as the PSNS publisher was their willingness to cooperate with an equipment house in making a joint arrangement for equipment supply, relieving PSNS of this burden. Again with the assistance of Mr. Carlyon, Damon and Wiley entered into contractual relations so that teachers now ordered experimental supplies directly from Wiley. Wiley has published an attractive equipment catalogue which is part of their promotional material.

One of the difficulties in promoting an experimental course in physical science is the cost of operating such a course. From a purely administrative point of view laboratories are a nuisance. They are expensive; they consume student and teacher time; they add to costs for equipment and for the provision of supervisory personnel. In spite of this situation, the Directors of PSNS believe that a course in science, especially at the beginning level, is not much of a course without student experimentation. It is difficult to evaluate all laboratory costs, but

equipment expense can be expressed on a cost per student basis. There are a number of variables to be considered: class size, number of classes which can use the same equipment at different times, expendable equipment which is used up by the individual student and capital equipment which may be used by generations of students. From its long experience i.. supplying equipment Damon has classified costs per student as follows.

Assume a bare laboratory which will accommodate at least thirty students, and which is supplied with bare tables, running water and 120-volt electrical outlets. The cost of equipment, both expendable and capital, would be, at catalogue prices,

for one section of 30	\$76.25 per student
for two sections of 30 (meeting at different hours)	46.75 " "
for three sections of 30 (meeting at different hours)	35.75 " "

Many institutions are able to supply some equipment from their own stockrooms. Furthermore, the use of capital equipmmnt over a number of years further reduces the average cost per student. A more realistic way of evaluating costs may be seen in considering the academic year 1969-70. The course was offered to about 13,000 students in about 150 schools many of whom were repeat- the course for the second or third time. The average cost, assuming that schools purchased supplies from Damon (generally true), was \$11.24 per student.

(5) Evaluation

In Section E there is a detailed discussion of our efforts to achieve an effective evaluation program for PSNS. At this point we will only give an estimate of the cost of the program.

The cost to the project for the abortive effort to arrange an evaluation program with Educational Testing Service was approximately $3,000.

The cost of the program with Dr. Wayne Welch, which will be completed in December, is estimated to be about $32,000, including the cost of widespread distribution of the report. Thus the total cost of formal evaluation is estimated to be about $35,000. Adding 15% overhead we obtain about $40,000 or about 5.9% of the total funding for the project.

2. The Role of Administration

During the whole course of the project, a conscious effort has been made to keep Administration from becoming the tail that wags the dog. An obvious method of measuring the importance of any operation is with dollars. It is difficult, however, to pinpoint administrative costs precisely. Let us consider the cost of maintaining the administrative office of the project full time at RPI during the five years and nine months of the project. This office has been staffed by the Director and his secretary. It is true that the Director has performed duties other than administrative ones. On the other hand, the Chairman of the Advisory Board, who has been in charge of the substantive part of the project, has performed many administrative duties. It is also

true that the Director and his secretary are the only staff personnel who have regularly received salary during the whole life of the project: The Director halftime and the secretary fulltime. Therefore, again, let us consider that the expenses of the administrative office constitute the administrative expenses. These expenses for the fulltime of the project are estimated to be $87,000 for salaries and $15,000 for communication and supplies. This gives a total of $102,000. Adding 15% overhead we have $117,300 or 17.2% of the total funding of the project.

C. MATERIALS DEVELOPMENT

1. Staff

The initial administrative staff in 1965 consisted of Professor Lewis G. Bassett of the Chemistry Department of RPI as director; Professor Robert L. Sells of the Physics Department of the State University of New York College at Geneseo as Associate Director, and Dr. Elizabeth A. Wood of Bell Telephone Laboratories as Associate Director and Chairman of the Advisory Board. The secretarial staff and graduate assistants were recruited by Professor Bassett and the materials-development staff was originally recruited by Dr. Wood. In the spring of 1967, Dr. Wood retired as Chairman of the Advisory Board. Her place was taken by Arnold A. Strassenburg, Professor at the State University of New York at Stony Brook and the Director of the Education and Manpower Division of the American Institute of Physics. At the same time Dr. Strassenburg became the third Associate Director and recruited the materials-development and editing staff for the remainder of the project.

In May, 1968, Professor Walter E. Eppenstein of the Physics Department at RPI became a codirector of the Project.

There follows a list of the PSNS Project staff with their dates of service and field of specialization.

The PSNS Project Staff (See Fig. C-1)

S. Aronson (physics) 1967-1968
Nassau Community College, Garden City, N.Y.

J.J. Banewicz (chemistry) 1965
Southern Methodist University, Dallas, Texas

L.G. Bassett (chemistry) Director, 1965-1971
Rensselaer Polytechnic Institute, Troy, N.Y.

W.E. Campbell (chemistry) 1965; 1967
Rensselaer Polytechnic Institute, Troy, N.Y.

E.L. Carlyon (physics) 1965-1968
State University of New York College at Geneseo, Geneseo, N.Y.

M.T. Clark (chemistry) 1966
Agnes Scott College, Decatur, Georgia

T.H. Diehl (science education) 1965
Miami University, Oxford, Ohio

W.E. Eppenstein (physics) 1965; 1967-68
Rensselaer Polytechnic Institute, Troy, N.Y.

D.F. Holcomb (physics) 1966
Cornell University, Ithaca, N.Y.

H.B. Hollinger (chemistry) 1967-1969
Rensselaer Polytechnic Institute, Troy, N.Y.

S.J. Inglis (physics) 1966-1969
Chabot College, Hayward, California

J.L. Katz (physics) 1965
Rensselaer Polytechnic Institute, Troy, N.Y.

H.M. Landis (physics) 1965-1969
Wheaton College, Norton, Mass.

S.H. Lee (chemist) 1965
Texas Technological University, Lubbock, Texas

A. Leitner (physics) 1967
Rensselaer Polytechnic Institute, Troy, N.Y.

W.J. McConnell (physics) 1966
Webster College, Webster Groves, Mo.

H.F. Meiners (physics) 1965
Rensselaer Polytechnic Institute, Troy, N.Y.

E.J. Montague (science education) 1965
Ball State University, Muncie, Ind.

Sister Bernice Petronaitis, O.S.F. (chemistry) 1966
St. Benedict's High School, Chicago, Ill.

L.V. Racster (chemistry) 1966-1969
Rensselaer Polytechnic Institute, Troy, N.Y.

A.J. Read (physics) 1965-1966
State University of New York College at Oneonta, Oneonta, N.Y.

R. Resnick (physics) 1965-1969
Rensselaer Polytechnic Institute, Troy, N.Y.

F.J. Reynolds (chemistry) 1965
West Chester State College, West Chester, Pa.

R.K. Rickert (chemistry) 1965-1967
West Chester State College, West Chester, Pa.

R.S. Sakurai (physics) 1965-1968
Webster College, Webster Groves, Mo.

J. Schneider (chemistry) 1966
St. Francis College, Brooklyn, N.Y.

R.L. Sells (physics) Associate Director 1965-1967
State University of New York at Geneseo, Geneseo, N.Y.

L. Smith (chemistry) 1965-1966; 1968
Russell Sage College, Troy, N.Y.

M.K. Snyder (chemistry) 1966
The Colorado College, Colorado Springs, Colorado

A.A. Strassenburg (physics) Associate Director 1966-1971
State University of New York at Stony Brook, Stony Brook, N.Y.
and American Institute of Physics, New York, N.Y.

P. Westmeyer (chemistry) 1965-1967
Florida State University, Tallahassee, Florida

S. Whitcomb (physics) 1967-1969
Earlham College, Richmond, Indiana

E. A. Wood (physics) 1965-1971
Bell Telephone Laboratories, Murray Hill, N.J.

E. Wright (science education) 1965
Montana State University, Bozeman, Montana

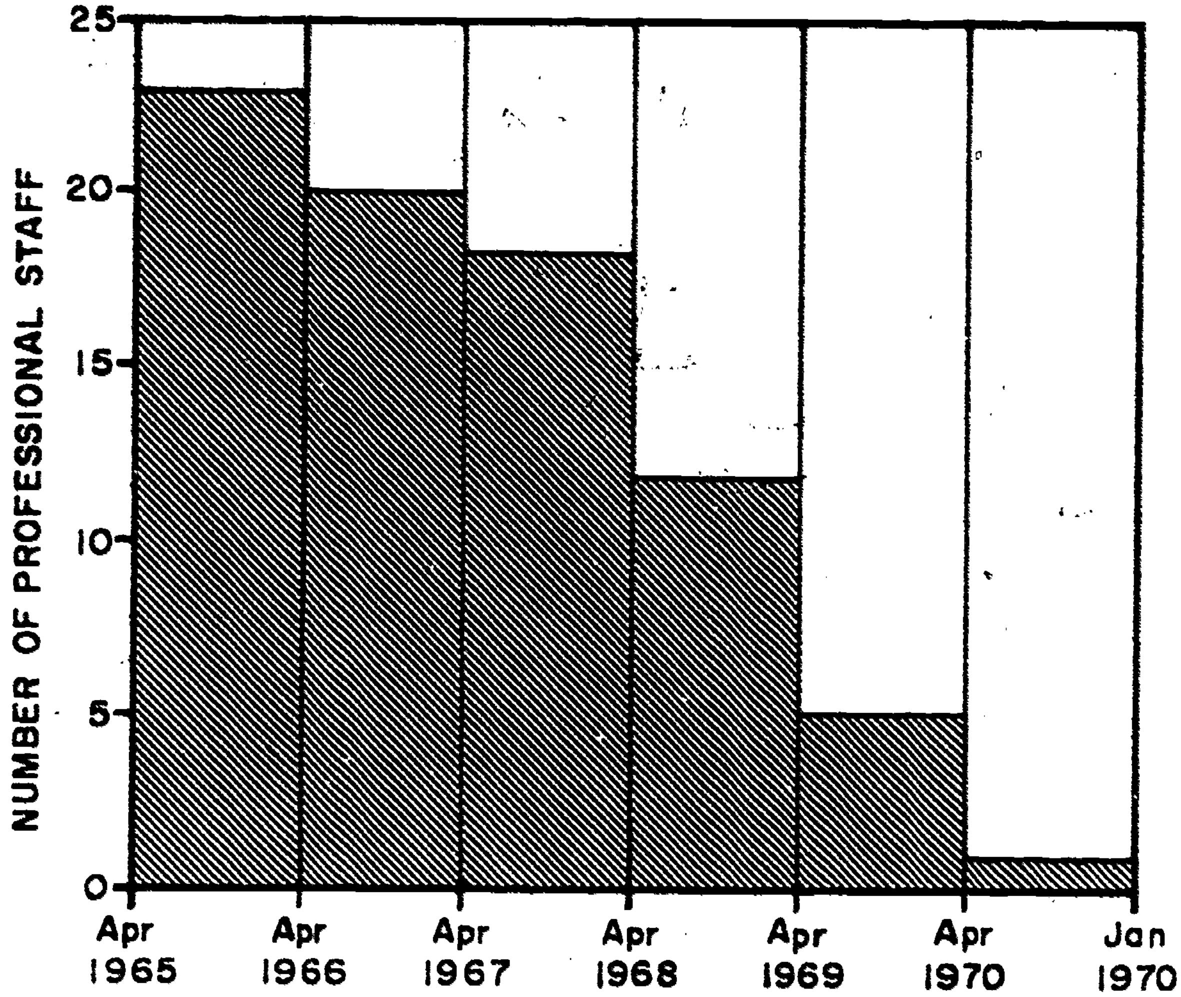


Figure C-1 Annual Numbers of Professional Staff

Service Staff

Ann Bazycki	Typist	Jun 1966-Sep 1966
Carol A. Bassett	Typist	Jun 1967-Aug 1967
Karen Carberry	Typist	Jun 1965-Sep 1965
Margaret Curley	Secretary	Mar 1965-Jan 1967
Frances Connors	Typist	Nov 1965-May 1967
Frances Feski	Secretary	Feb 1967-Jan 1971
Dolores Guerin	Typist	Jun 1966-Sep 1966

Linda Meier	Typist	Sep 1967-May 1968
Nancy Smith	Typist	Jun 1966-Sep 1968
M. Bailey	Draftsman	Jun 1966-Sep 1966
William Barber	Student Assistant	Jun 1968-Aug 1968
Dennis Cole	Draftsman	Jun 1965-Sep 1965
Larry Dombrowski	Student Assistant	Jun 1965-Jun 1966
Kathryn Egloff	Student Assistant	Oct 1966-May 1967
G. Lavis	Shop Manager	Jun 1965-Sep 1965
Ronald A. Kent	Graduate Assistant	Feb 1967-Jun 1967
Edward C. Nathan III	Lab Assistant	Jul 1966-Aug 1966
J.C. Walling	Lab Assistant	Jun 1965-Sep 1965
Howard D. Wolper	Student Assistant	Jun 1967-Sep 1967
David Wos	Lab Assistant	Jun 1965-Sep 1965

2. Procedures

This section is written with the hope that a description of procedures that produced favorable results may be useful to those undertaking similar projects in the future. It is organized in chronological order. Because getting started is probably the most diff.cult procedure, special attention is given to the initial period.

a. Prior to the Beginning of the Project, April, 1965

As soon as favorable action on the project proposal seemed probable, a meeting was held at the American Institute of Physics (on Feb 15 and 16, 1965) to which were invited all those who had agreed to work as members of the materials-development staff, as well as members of the Advisory Board and a few others who had indicated more than casual interest.

The purpose of this meeting was to focus the attention of all present on the task of the project with the hope that ideas concerning it would start simmering in February and come to a boil in June when actual materials development would begin. It was expressly stated that the purpose was to get a running start on the summer's work. The costs of this meeting were defrayed by the Commission on College Physics.

Some of the actions of this meeting were:

(1) Choice of the name Physical Science for Nonscience Students (PSNS) Project

(2) Agreement on E.A. Wood as Chairman of the Advisory Board and leader in developing the substantive part of the project

(3) Consideration of the criticisms of reviewers of the proposal

(4) Listing of equipment and resource needs for the summer

(5) Agreement to distribute preliminary questionnaires to about 2000 students currently enrolled in college courses in physical science for nonscience students (See Appendix C-1)

(6) Consideration of various modes of working during the summer

(7) Consideration of working facilities and housing accommodations at Troy as described by Professors Eppenstein and Bassett, respectively

(8) Consideration of a tentative list of subdivisions (Chapters?) of the ''Main Stem'' material with ''First Hand Experience'' associated with each. A list of possible ''Packages'' (subsequently called Supplementary Chapters) was also considerd. Participants were urged to think about the parts they would like to work on.

(9) Agreement to have a detailed planning meeting early in May

Funding of the project began in April, 1965.

b. Spring, 1965

A detailed planning meeting lasting two days was held at RPI in Troy before the 1965 summer writing session. Chapter titles were tentatively listed and staff members chose those they wished to work on. Two or three members were assigned to each of the eighteen chapters. In each case, one was assigned primary responsibility. The important function of this meeting was to clarify in each member's mind the nature of the work he would be doing during the summer so that he would arrive ready to proceed. From the beginning of the project, it was understood that no author identification for portions of the text would be published and that the editorial board was free to revise text as extensively as it deemed necessary, without having to consult the original author or authors.

c. Summer, 1965

Members of the project worked in small offices holding two to four people. Two large work rooms, with library and tables, were communally available, as was a chemical laboratory.

The several hundred questionnaires (Appendix C-1) that had been filled out by nonscience students were available and members of the staff were urged to read them before starting to write, and at intervals throughout the summer so as to keep clearly in mind the backgrounds and attitudes of the students for whom they were writing.

Most of the students had indicated that they expected to do poorly in the course and to dislike it, but that, since it was required, there must be some purpose to be served by taking it. Most were not familiar

with fractional and negative exponents. The equation $2X = 4$ was correctly solved by nearly all students, but many were unable to solve the equation $\frac{330}{X} = 11$ even though some of these listed algebra as one of the mathematics courses they had taken.

Most students identified horizontal as ''east-west'' or ''left-right'', but some identified ''vertical'' in this way. ''Precipitate'' meant ''rain or snow'' to most and at least three students defined ''viscous'' as ''cross and angry like a viscous dog''.

Occasional perusal of the questionnaires kept the writing at a realistic level.

Before the end of the first week it became clear that each author needed to have a fuller picture of all other authors for their respective chapters. This was discussed in a staff meeting, and it was agreed that each would spend a couple of days making a rather detailed plan of the contents of the chapter for which he had major responsibility. There followed a two-day staff meeting at which we ''talked the course through'' from beginning to end, with each person describing his plans. Overlaps and gaps became evident and problems were resolved.

Although this procedure seemed to be time-consuming it was extremely valuable. From this point on, the members proceeded with confidence to develop materials for the various chapters and knew whom to go to for discussion of possible overlaps or prerequisite coverage.

First-draft material was typed, duplicated, and a copy given to every member of the staff. Members were urged to read this material quickly, making marginal comments, and return the copy to the author.

Mail boxes, frequently consulted, facilitated communication. Late in the summer, as the volume of written and rewritten materials increased and the fall deadline drew near, much of the material was not read by every member of the staff. However an editorial board consisting of the Director, the Associate Directors, Lois Smith and sometimes various other members of the staff, read all completed chapters.

Commercially available films, chosen for possible relevance to the PSNS materials, were shown on one afternoon a week. Blanks for written comments were distributed to all members and filled out immediately following the viewing of each film. These formed the basis of subsequent recommendations of films for use with the PSNS materials.

During the summer several consultants visited RPI, each for one or two days at a time. These were: H.R. Crane of the Physics Department of the University of Michigan, T.D. Goldfarb of the Chemistry Department of the State University of New York atStony Brook, J.R. Haynes of Bell Telephone Laboratories, D.F. Holcomb of the Physics Department of Cornell University, N.J. Kutzman of Montana State College, Frank Sinden of the Mathematics Department of Bell Telephone Laboratories, A.A. Strassenburg of the Commission on College Physics, and J.H. Werntz, Director of the Minnemast Project, University of Minnesota.

These visits were originally planned with the thought that they would provide a change of pace and needed stimulation for those producing PSNS materials. Further, it was thought that it would be helpful to the members of the staff to have to describe to an outsider their plans for the materials for the course. It developed, however,

that those members of the staff who were most actively producing materials needed no stimulation and felt that the visits resulted in a loss of much needed time. Those members of the staff who were less productive were not made more so as a result of the visits by consultants. This is not to say that the consultants themselves were at fault. All of them were earnestly interested in the project and the discussions with them were interesting and enjoyable. In view of the desirability of maximum effective use of time and money, however, it was decided not to have consultant visitors during subsequent summers.

Some of the material was tried out on undergraduate students available during the summer at the State University of New York College at Geneseo. These students were paid to read portions of the text and perform some of the experiments and to give constructive criticism of these materials. The usefulness of this procedure was not such as to warrant its repetition another year.

d. Winter, 1965-66

Six of the summer staff members agreed to trial-teach the course during the following academic year and another teacher with whom we were in close communication was also accepted as trial teacher. Some of the chapters and materials for experiments were ready for use. However, most needed rewriting, which was achieved by a small group, usually comprising the Director, two Associate Directors and two or three other members of the staff (usually, S.C. Bunce, H.M. Landis, and L.V. Racster), meeting for a series of two-day sessions throughout the winter. This group worked through each chapter, sentence by sentence, then had it typed,

and printed by duplicating services at RPI. In this way the First Preliminary Edition was printed in five paper-covered volumes. The production of these lagged behind the need for them.

Most of the equipment was assembled by E.L. Carlyon with the aid of his family and students and personally packed and mailed by him. Some of it was collected, packed and mailed by E.A. Wood, who also kept in touch with the trial teachers through personal letters of encouragement and advice concerning the revised versions of the chapters and the use of the equipment and supplies.

Keeping the seven courageous teachers supplied in time for their classes was a hand-to-mouth operation, fraught with anxiety. However, this early trial gave us very valuable feedback that made the work session of 1966 much more effective than it could have been without the trial.

Professor Stuart Whitcomb of Earlham College, which is on the trimester system, asked permission to try the PSNS materials in the latter part of the academic year 1965-66. Although he had not been associated with the project,he had seen the materials and was anxious to teach the course. This was subsequently arranged and Earlham College became the eighth trial college in the year 1965-66.

Feedback from the trial teachers came throughout the year in personal letters, but a one-day meeting was held in January of 1966 for more direct reports while their experiences with the first semester of the course were still fresh in their minds.

e. Summer, 1966

Some changes were made in the PSNS staff for the second summer, as indicated in the periods-of-service listing of the members of staff (see Section C-1).

The eight trial teachers spent the first week of the summer session with the members of the staff, going through the text, chapter by chapter, and describing the successes and difficulties they had experienced in using the materials. Revision of the materials during the summer of 1966 was based on this feedback.

A looseleaf Teachers' Resource Book was produced during the summer and fall of 1966. Each chapter author was asked to contribute notes concerning his chapter, but the production of the book was the responsibility of H.M. Landis.

Although the production of Supplementary Chapters was part of the original plan for the course, no work was done on these during the first summer (1965) because production of the main stem material had higher priority. Work on the Supplementary Chapters began in the summer of 1966. Unlike the procedure for writing the main text material, the procedure for producing a supplementary chapter was to assign the writing of it exclusively to one author. However, as with the main text, the printed version of the Supplementary Chapters carries no indication of authorship.

ACIDS AND BASES, written by Professor Lois Smith, appeared in paper-covered booklet form in the fall of 1966. A 1966-67 trial of it was considered desirable, but none of the trial teachers had time

available for it. Preliminary work on a supplementary chapter on MAGNETISM was undertaken by Professor Donald F. Holcomb at Troy during the summer of 1966.

During the last two weeks of August, 1966, a Briefing Session, under the direction of A.A. Strassenburg, was held for 23 teachers planning to teach the course during the academic year 1966-67 (see Section E).

f. Winter, 1966-67

During the winter of 1966-67, the editorial board went over the text, chapter by chapter, editing the revisions that had been produced during the 1966 summer session. The text was printed by Fort Orange Press of Albany in three volumes whose appearance again lagged behind the needs of the teachers. Although the first volume was available for the opening of classes in the fall, the third volume did not appear until May, too late for use by most of the trial teachers. Earl Carlyon, working in close cooperation with Damon Educational Corporation, endeavored to keep the teachers supplied with equipment ahead of their need for it.

Feedback was collected from the 23 teachers by mail, telephone, and in two feedback meetings: one at Fairleigh Dickinson University on Feb 3 and 4, 1967 and one at RPI on Jun 11-16,1967. These were chaired by A.A. Strassenburg who had replaced E.A. Wood as Chairman of the Advisory Board and as the Associate Director having responsibility for the form and substance of the materials. Dr. Wood continued as an Associate Director, but resigned from the more demanding

posts in anticipation of a five-month absence from the country.

During the winter and spring of 1966-67 John Wiley and Sons were selected as publishers (see Section B).

g. Spring and Summer, 1967

On the basis of feedback from the 23 trial colleges the third and last preliminary, paper-covered edition of the text was produced. It appeared in two volumes and was published by Wiley in the same format as that of the previous preliminary edition. Copy for the first volume prepared during the winter of 1966-67 by the editorial board, was supplied to Wiley in the spring. Copy for the second volume was prepared during the summer of 1967, with Stuart J. Inglis having primary responsibility for editing. This edition was used during the academic years 1967-68 and 1968-69.

A staff of about 18 members worked at RPI during the summer of 1967. H.M. Landis had charge of editing a preliminary edition of the Teachers' Resource Book which was printed by Fort Orange Press.

During this summer the supplementary chapter on MAGNETISM was extensively revised by Professor Strassenburg and was printed in paper-covered booklet form.

The supplementary chapters MATTER IN THE ASTRONOMICAL REALM, written by Professor Inglis, and MATTER IN THE EARTH, written by Dr. Wood, had gone through several preliminary drafts and were published in paper booklet form in the fall of 1967.

A Summer Institute for prospective teachers of the PSNS course was conducted at RPI in 1967 under the direction of S.C. Bunce and

A.A. Strassenburg (see Section E).

h. Winter, 1967-68

The course was used in approximately 40 colleges during 1967-68. For the first time, the equipment was not subsidized and the textbook was only partly subsidized. For this reason, the teachers were not required to provide feedback. The Teachers' Resource Book was furnished free of charge.

During this period Stuart J. Inglis worked as a fulltime member of the staff, preparing a final revision of the text for hardback publication by Wiley. This involved numerous meetings with Wiley concerning format, illustrations, etc. As galleys became available they were proofread by Bassett, Inglis, and Strassenburg.

i. Summer, 1968

The PSNS staff for the summer of 1968 at RPI comprised about 12 members. Proofreading of galleys for the final edition was completed. A complete revision of the Teachers' Resource Book was produced and edited by a team headed by H.M. Landis.

Dr. Susan V. Meschel, who had taught the PSNS course at the University of Chicago, critically read all of the written materials for accuracy and appropriateness of content, acting in a consultant capacity. Her comments were useful in the preparation of subsequent editions.

A second Summer Institute for prospective teachers of the PSNS course was held at RPI (see Section E).

j. Winter, 1968-69

Page proofs of the final edition of the text and Teachers' Resource Book were read by Bassett and Strassenburg. The text, AN APPROACH TO PHYSICAL SCIENCE was published in hard covers in January, 1969, by John Wiley and Sons, and their publication of a revised edition of the paper-covered Teachers' Resource Book followed shortly thereafter.

A supplementary chapter on EQUILIBRIUM, which had been produced in first draft by R.K. Rickert and L.V. Racster during the earlier summer sessions, was extensively revised by H.B. Hollinger during the academic year 1968-69.

The PSNS ccurse was taught in about 50 colleges during the academic year 1968-69, the first year in which the materials were not subsidized in any way.

k. Summer, 1969

During the summer of 1969 five members of the PSNS staff worked on completing the Supplementary Chapters. These were published by Wiley in 1970, as was a final edition of the Teachers' Resource Book which included resource material for the supplementary chapters.

A supplementary chapter on GEOMETRICAL OPTICS which had been produced in first draft by H.M. Landis was revised by A.A. Strassenburg during the summer of 1969. First drafts for three additional supplementary chapters had been produced during the course of the project. These chapters would have been entitled AVOGADRO'S NUMBER, BIOLOGICAL MOLECULES and THE NUCLEUS. All of these were critically read and con-

sidered. It was decided that the material subsequently added to the main text on Avogadro's number and biological molecules treated these subjects as deeply as was desirable for the PSNS students. After considerable discussion of the available published material on the nucleus, the desirability of producing a special essay on it for PSNS was questioned. It was decided to provide in the Teachers' Resource Book an outline of a unit on the nucleus and references to available published materials. As a result, the supplementary chapter on THE NUCLEUS was not published.

3. Content

a. Guidelines that Influence the Choice of Content

(1) Attitude Goals

(a) To change the attitude of the students toward science from one of confusion, anxiety and dislike to one of confidence and interest; hopefully, to convince the students that science is fun.

(b) To convince the students that science is observation and wondering; asking questions about the world around us and designing ways of discovering answers to them, not just memorizing facts. They should feel confident of their own ability to successfully seek answers to questions about the natural world. This is especially important for the large numbers of students who will become elementary-school teachers. They must feel confident that they are doing a good job when they encourage the natural curiosity of the children, rather than feeling a sense of panic lest the children ask some question whose answer they have not memorized.

(c) To convince the students of the self consistency of science, the fact that it all fits together to make sense; that the Universe is not a capricious Universe in which the Earth may suddenly stop rotating or gravitational forces cease to act.

(d) To have the students experience experimental (laboratory) investigations and gain confidence in their own observations and their ability to analyze them. They should get a sense of how we know what we know. Science is not based on authority but on repeatable experiments.

(2) Substantive Goals

(a) To encourage the observation of natural phenomena among college students who are nonscience majors.

(b) To teach nonscience students how to formulate questions about physical situations.

(c) To teach nonscience students how to propose models and hypotheses consistent with their observations.

(d) To teach nonscience students how to design simple, controlled experiments to test their hypotheses.

(e) To teach nonscience students how to analyze experimental results.

(f) To provide for nonscience students a basis for recognizing the limitations of science.

(3) Subject-matter Guidelines

(a) In order to give time for the achievement of the important goals listed above, much of the subject matter that is commonly packed into the science course for nonscience students must be omitted.

The goal is not to teach the students as many facts as possible. A choice of subject matter must be made which best serves the goals listed above.

(b) In keeping with the title of Physical Science, the subject matter chosen should lie mostly in the overlap area shared by physics and chemistry and should, insofar as possible, be unidentifiable as belonging to either field.

(c) For logical coherence a major focus of study should be chosen, to which all subject matter of the course contributes in a demonstrable way.

(d) The focus of study should be one rich in opportunities for first-hand experiences (laboratory) with familiar materials where possible and with simple equipment.

Although these goals and guidelines were not explicitly stated when the course was originally outlined, they formed in fact the basis for its conception. The original concept of the content of the PSNS course is given in Appendix A-3 which is taken from the report of the 1964 Conference at Boulder, Colorado.

In meetings just prior to the writing of the proposal for funds, this outline was drastically modified by a number of college teachers of physics and chemistry, who added to it and rearranged it until it resembled the more familiar survey course. Subsequently, a small group pointed out that the innovative character of the original content plan had been lost and recommended returning essentially to the original plan. As a result, the content plan appearing in the proposal for funds was essentially that proposed at the Boulder Conference.

The chosen focus of the course was the study of solid matter, how it gets the way it is, how it behaves when you do things to it, and how we find out about it. This is a vertical approach, beginning with tangible investigation of familiar substances in simple ways and gradually increasing in sophistication through the course as students hopefully gain confidence. This is not the horizontal approach of the fact-skimming survey course.

The focus is not so sharp as to exclude subject matter that is useful to us in learning about solids. What heat does to solids leads to the study of liquids. The easiest way to learn something about thermal motion in solids is through studying the behavior of gases. In order to think clearly about the forces that hold solids together, some elementary mechanics and some experiments in electricity (electrostatics, circuits, and electrolysis) are needed. The course culminates in a study of the relation between the structure of a substance (the arrangement of its consituent atoms) and its properties.

Although we believed that the study of solids is a particularly favorable approach to physical science for the reasons just mentioned, we called the attention of the students to the fact that other approaches might also be fruitful, and emphasized the significance of the title of the text, which is not The Approach to Physical Science, but AN APPROACH TO PHYSICAL SCIENCE.

Certain ''threads'' which run through all of science were consciously identified by the PSNS staff with the aim of calling the attention of the student to them whenever the opportunity to do so could

be found.

These were:

The beauty of the orderliness and self consistency of the Universe.

Symmetry, its beauty and its power as a tool.

The Conservation Laws.

The uses of mathematical expression.

The power of the technique of making models, both physical and mental.

To motivate the nonscience student to want to proceed with the study of science is difficult. In the initial conception of the course, the question of the boredom of the nonscience student in a science class was considered. Real scientific investigation has all the fun of a treasure hunt or a mystery story. The investigator follows up clues with enthusiasm because he needs to know what they can tell him. An early decision was made that the need to know should be a guiding restraint on the choice of content of the course and on its arrangement in the text.

In real scientific investigation the answers do not usually come quickly. In many cases even the means for seeking them cannot be devised and the problem is put on the shelf for a while. To have a question in the back of one's mind, gently nagging for an answer, is an experience familiar to any research scientist. It places him in a state of readiness for seizing upon a clue to the answer when it comes to light in some unexpected form. Students are seldom allowed to experience this important process. Commonly, in school and college

courses, questions are not raised and left unanswered. In the PSNS Project an early decision was made that, from time to time, a question should be placed on the shelf to be reconsidered later when further experiences had better prepared the minds of the students to deal with it.

A third pedagogical technique of the PSNS course grew out of the recognition that most of us learn helically. We may gain only superficial understanding of a process or concept on first acquaintance with it. When we next encounter it, there is the pleasure of familiarity to enhance our interest. Here it is again. Our understanding of it deepens. The repeated consideration of a concept or process, the here it is again technique, was consciously employed by the PSNS staff in writing the text.

b. Resulting Materials

Three kinds of printed materials were produced by the Project: the Text, AN APPROACH TO PHYSICAL SCIENCE, of which the experiments form an integral part; the SUPPLEMENTARY CHAPTERS, provided for those teachers who have the time and interest to teach some material related peripherally to the focus of the course, but not included in the mainstem text; and the TEACHERS' RESOURCE BOOK, including useful background material, suggestions for laboratory procedure, homework questions, etc., for the teacher, both for the material of the main text and for that of supplementary chapters. The sequences of the development of the various printed materials for the course have been described in Section C-2 and are shown diagrammatically in Figure C-2. The Tables of Contents of all editions of the text and of the Supplementary Chapters constitute Appendix C-2.

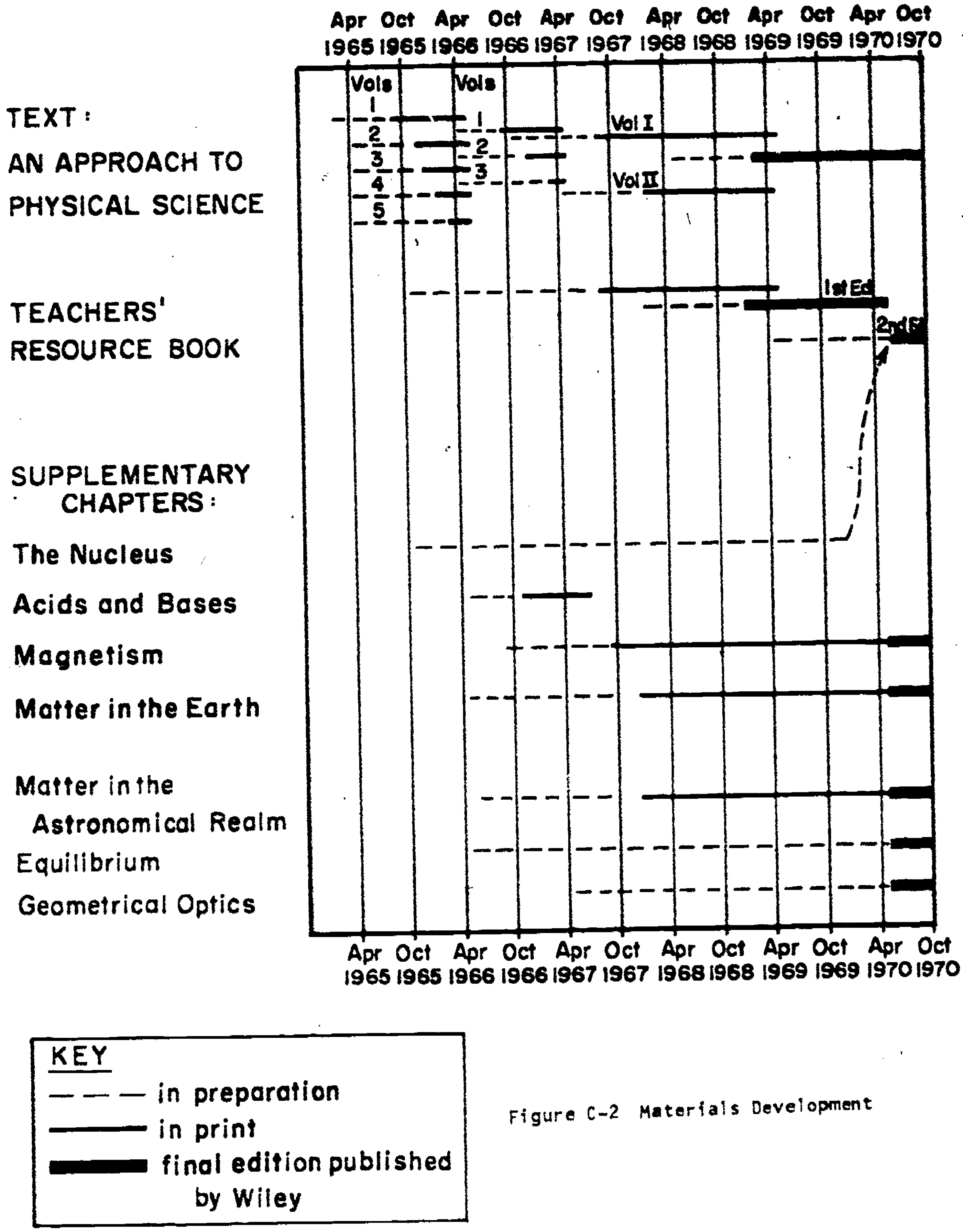


Figure C-2 Materials Development

c. <u>Illustrations of the Ways in Which the Materials Were Moulded by the Goals, the Guidelines and the Feedback</u>

Comparison of the Tables of Contents (Appendix C-2) gives some suggestion of the evolution of the final form of the materials. However, text changes do not always result in changes of the Table of Contents, and changing the title of a section does not necessarily result from a change of text. A few examples will serve to show the responsiveness of the PSNS staff to the guidelines and to the feedback.

Chapter 1 was considered especially important as a means of (1) convincing the student that <u>this</u> science course was not going to be impossibly difficult for him, and (2) sharing with him very sincerely our goals and guidelines.

Feedback from the first edition indicated that some of the students found the tone of voice of the first chapter condescending. The offending passages were modified for the second edition. Feedback concerning the second edition came from a larger number of colleges. Little complaint remained concerning the tone of voice of the chapter. The students found it interesting, but were concerned about ''what they were supposed to have learned'' from it. They thought they understood it, but wondered how they could be examined on it. In response to this concern a ''Summary'' section was added in the third preliminary edition which listed six ideas developed in Chapter 1 ''that will be useful as you continue the course''. More problems were added, to give them a sense of concrete achievement.

Chapter 4 on interference of light was another chapter requiring special attention. This is the first chapter in which more

sophisticated ideas and quantitative consideration are introduced. In the first edition it was very long, including some peripheral illustrative material, intended to be helpful, which confused the students. Algebraic and trigonometric expressions added to its formidable appearance and the students were turned off by it.

As a result of feedback this chapter was completely rewritten. Teachers using the second edition reported that students found this chapter difficult, but nearly all of them were able to work through it successfully, and they experienced a sense of achievement as a result. Up to that point some students had worried because they thought a course that was really science should be almost impossibly difficult, and this one was not. Chapter 4 reassured them.

In the course of preparation of the Third Preliminary Edition the staff asked why ''multiple-object interference'' occurred in Chapter 4 when the need to know about it did not come until the story of the discovery of x-ray diffraction in Chapter 6. So the last two sections from Chapter 4 in the Second Preliminary Edition were removed to the place in Chapter 5 where the story of the von Laue experiments gets to the point where the reader needs to know about the experimental observations of interference of light scattered from regular arrays of slits and regular arrays of objects.

In the first edition MATTER IN MOTION (mechanics, forces and energy) appeared as Chapter 7, providing the tools for handling MOLECULES IN MOTION (Chapter 8) where solids, liquids and gases were discussed in terms of a particle model. This prepared the way for SOLID

MATTER: A CLOSER LOOK AT DIFFERENCES (Chapter 9) which discussed properties of substances, especially with regard to their behavior when heated and their electrical conductivity. During the preparation of the Second Preliminary Edition, the staff looked critically at this sequence and decided that it was not in accord with taking up subjects when the student had a need to know about them. ''Why not take the object in hand and discover its properties first?'' They asked. This leads to trying to make a model consistent with experimental observations. In considering a particle model one finds he needs a way of considering forces between particles, and only then is the MATTER IN MOTION Chapter needed.

As a result, in the Second Preliminary Edition, MATTER: A CLOSER LOOK AT DIFFERENCES appears as Chapter 7. It is no longer restricted to solid matter, since heating solids leads us without a logical break into considering liquids and gases. MATTER IN MOTION becomes Chapter 8 and the last paragraph of Chapter 7 points the way: ''We began studying gases to learn more about their behavior. We hoped that this would eventually give us a better understanding of the structure of matter, particularly solid matter, and the relationship of structure to properties. Now we need to find out exactly what we mean by force and pressure in order to pursue our study of gases. We will do this in the next chapter.'' After a few words about atoms the student reads that ''Since atoms are so small that they are invisible, we will first consider the motion of and forces on ordinary-sized things.'' Now the student finds himself pushing and pulling carts, nearly halfway through the course when he has a need to know about forces, not at the beginning of the course when he does not.

The emphasis on the need to know principle in the above examples reflects its importance as a guiding principle throughout the PSNS project. Some examples of the influence of other guidelines follow.

A good example of the on the shelf technique is found in the chapter on interference of light. Each student observed the interference fringes when he held the double slit between his eye and an incandescent filament, both with and without color filters. The text proceeds as follows: ''Question 4-1: What type of pattern would you expect to see if the light were considered to be a large number of small particles coming through two slits? Does this agree with your observations?

''Young considered both the particle and the wave theories and decided that only the wave model of light was consistent with the interference pattern observed. To see what led to this conclusion we must take a closer look at the nature of waves.''

This, then, leads into a discussion of superposition of waves and only after this subject has been explored do we return to interference, in the section ''Interference Revisited'' in which we ''consider a water-wave experiment that is analogous to Young's double-slit experiment.'' During all of this, the observations made by the student in the double-slit experiment are on the shelf of his mind, gently nagging for an explanation.

In the Teachers' Resource Book (TRB), whose contents will be discussed later, encouragement is given to the teacher to raise questions which will have to be put on the shelf to await fuller experience.

For example, in connection with the initial chair-arm experiment in which the students grow salol crystals from the melt on a glass slide, the TRB suggests, ''Some questions to direct student attention along lines we will investigate during the course are: 'How does it happen that they all have the same shape?'; 'Why do they grow with large, flat faces that reflect the light?' It is quite remarkable that out of each formless puddle of liquid salol the same shiny-faced solid is built up each and every time the crystals form.''

Scientific explanation is the process of constructing a mental model consistent with one's observation. The attention of the student is constantly called to this use of models. We can take an example from the chapter ELECTRIC CHARGES IN MOTION.

''Although our discussions of electric current may seem to have no relation to the structure of solids, we are now able to describe the energy losses as a charge flows through a solid conductor. But what kind of charge - - positive, negative, or both? Without some kind of model for the means by which charge is transferred through solids, we cannot answer this question. In fact, this model is an important part of an understanding of the structure of solids.''

An example of the <u>here it is again</u> experience relates to the shapes of crystals. In Chapter 1 crystal-growing experiments are performed by the student. The teacher calls his attention to the shapes of the salol crystals as he grows them in a chair-arm experiment, and the characteristic shapes of several other kinds of crystals are explored in Chapter 5, CRYSTALS IN AND OUT OF THE LABORATORY. At

this stage, the relation of shape to some sort of regularity (as yet unidentified in detail) within the crystal is developed. In Chapter 15 with a background which now includes experience with x-ray diffraction and bonding forces, the student again grows crystals, observing them as they grow. At this point, "Having recognized that crystals of different materials have different shapes, we want to relate these shapes to the arrangement of ions within the crystal. Before we can determine a detailed arrangement of ions, however, we must identify the ions in the crystal and then establish their relative numbers." Here again the need to know leads us into an example of qualitative and quantitative chemical analysis.

An example of one way in which the attention of the student is called to the threads which run through all of science is found in a footnote to the instructions for the Young's double-slit experiment. The instructions read, in part: "The simplest way to make these two slits is to hold two razor blades tightly together and (using a second microscope slide as a guide) draw the razor blades lightly across the graphite-coated surface so that the slits are parallel to the short edge of the slide. Scratch several of these slits to make sure you get one good pair. Use your magnifier to look at the slits and estimate the ratio d/w of the distance d between centers of the slits to the width w of each slit opening."

The footnote reads: "Note how the expression d/w helps to clarify the meaning of this sentence. This is an example of the usefulness of mathematical notation." A science student gradually

deepens his appreciation of the usefulness of mathematical notation throughout his educational experience. For these nonscience students who come to us with an aversion to mathematics its usefulness must be explicitly pointed out.

Certain other characteristics of the text should be mentioned, since they resulted primarily from feedback from the early teachers of the course.

(1) Appendices to the text

There are three appendices to the text. Two are tutorial, to strengthen the background of the students where it has been found to be especially weak. These are Appendix A, Review of Powers of Ten, and Appendix B, Graphs. An appendix reviewing elementary algebra might have been useful. The Periodic Table constitutes Appendix C. Some members of the staff felt that the inclusion of this table was contrary to the philosophy of the course, but others felt that it was needed.

(2) Questions

Questions appear throughout the text and also at the end of each experiment and the end of each chapter. In addition, further questions are suggested in the Teachers' Resource Book, for homework and examinations. Originally, the questions in the body of the text were not numbered, but some of these were rhetorical, to be answered in the text that followed, and some were intended to provoke serious thought on the part of the students. From feedback we learned that neither the students nor the teacher considered it necessary to answer

this second type. In later editions, therefore, we numbered them, with the hope that teachers would assign them for homework. Since we do not have feedback concerning the latter editions of the text, we do not know whether we achieved our objective.

Types of questions vary widely: In Chapter 1 is a question which requests dictionary definitions of some words we plan to use and which we have reason to believe might be misunderstood. In the same chapter ''Devise a means of classifying buildings'' is an example of an open-ended question. Some questions help the students become aware of the the structure of the course and of their own development. For example, ''4-26. What concepts from Chapter 3 were necessary to understanding of Chapter 4?''

Quantitative problems are not avoided where they can contribute to understanding. These vary in difficulty. Two of the simpler questions are: ''8-4. Calculate how far the puck traveled during the first 2 seconds of travel,'' and ''14-4. Write an equation which describes the change of an aluminum atom to an Al^{+3} ion.'' Two of the more difficult questions are: ''11-25. If you hold a plastic rod with a negative charge of 1.0×10^{-6} coulomb (one microcoulomb) in one hand, and in the other hand you hold a glass rod with a positive charge of 1.0×10^{-6} coulomb, with what force will they attract each other? The distance between the charges is 2.0 meter,'' and ''15-24. Potassium bromide has a cubic structure like that of sodium chloride. The density is 2.8 g/cm³ and the unit cell is 6.6 Å (6.6×10^{-8} cm) on each side. Find the masses of the potassium and bromine ions.''

(3) References

No references to further reading were included in the First Preliminary Edition of the text. The choice of references was given careful attention during the second writing session, and all subsequent editions carry references at the end of each chapter. In each case, the particular pages that are relevant to the preceding chapter and at an appropriate level for PSNS students are cited. The references are always annotated in the Teachers' Resource Book and sometimes are in the students' text.

d. The Teachers' Resource Book (TRB)

The content of the Teachers' Resource Book has not yet been discussed. Its table of contents is identical with that of the main text, since the TRB is meant to be used in parallel with the text.

A competent experienced teacher, thoroughly familiar with the PSNS materials asserts that he found the material in the TRB essential to the successful teaching of the course.

Experiments are described in enough detail so that a graduate student can set up the necessary equipment. A list of equipment is given, and in some cases, the time required for the experiment. Notes based on feedback from the trial teachers are included. For example:

''The experience of previous teachers indicates that it is best to have the students determine d, the distance between the slits, as a class project. Place 20 razor blades and a ruler or meter stick at some central spot in the room. Then during the lab period, have

students go there one at a time and measure the thickness of the pile of blades. After they all have had an opportunity to measure, they should record this information and determine the average value of the blade thickness d. This value should then be used by all students."

Warning is given concerning any hazards to health or equipment. For example: In the experiment on heating of wood splints, "The gas produced is somewhat noxious and should be prevented from escaping into the room by burning or collecting it." Also, "Be sure to remove the stopper and glass tubes from the condensing tube before the heating of the splints is stopped. This will prevent the cold liquid from being pushed up into the hot test tube. Safety glasses should be worn during this experiment."

The questions appearing in the text are repeated in the TRB. Answers to questions are given in the TRB and those who wrote the answers kept in mind the wide range in background we had found among those teaching the course. For example:

> 7-19. Why were you advised to wait 10 to 15 seconds after you stopped heating before taking the temperature reading?
>
> Answer. The instructions suggest that heating be stopped 10 to 15 seconds before determining the temperature and volume in order to allow the system to come to thermal equilibrium.

The reason for stopping is not given in the instructions. Keeping in mind the teacher with weak background, the TRB continues:

> The transfer of heat through the glass is relatively slow, and time must be allowed for all parts of the apparatus to come to the same temperature.

The more sophisticated teacher is repeatedly reminded in the TRB to tailor his expectations of answers to the students' level of development. For example, with respect to classificiation on the basis of solubility in Chapter 1, the TRB warns, ''There is not much to be done at this stage to aid the student in extending his ability to determine solubility more accurately than simply 'very soluble' and 'apparently insoluble', and he should be made aware that such a classification is very gross.''

Most teachers of science for nonscience students cannot really believe the severity of the difficulties their students have with mathematics. Many of the students react with a mental block to anything that resembles a mathematical equation. When equations are encountered in the text, the TRB gives, in detail, the step-by-step procedure advised in their discussion.

An example is found in the answer to Question 2-3: ''The density of dry air at normal atmospheric pressure and at 20°C is given as 1.20×10^{-3} g/cm^3. What is the mass of air in one cubic meter?'' (a nice question because of the astonishing answer, 1.20 kg). The TRB states: ''Because this is one of the first problems involving conversion of units and the use of exponential notation, it is

advisable to take class time to work out the algebra, the conversion of units, and the use of powers of ten. It also emphasizes the use of units to check on the dimensions carried along. It would probably be well to call the students' attention to Appendix A in the text.'' (Appendix A is a Review of Powers of Ten.) The steps we believe to be needed by the students are given. For example, in converting from cubic meters to cubic centimeters, the TRB provides the following detail: 1 meter^3 = (100 cm)^3 = 10^2 (cm)^3 = $10^2 \times 10^2 \times 10^2$ cm^3 = 10^6 cm^3.

Examples have been given of the way in which the text points out to the student the reason for taking up a particular topic. The teacher, accustomed to a sequence of topics in which preparation is given far in advance of the need, requires reassurance periodically concerning the PSNS philosophy and its effect on the content sequence. For example, in the TRB notes on Chapter 6 (WHAT HAPPENED IN 1912), we read: ''In keeping with the philosophy of the course, the subject of multiple-slit interference was not treated in Chapter 4, where it would seem logically to fit, but is presented only at the moment that the student needs to know about it. It may seem that it would have been easier or better to lay the groundwork before starting the story, but laying groundwork for something before there is any apparent need for it often makes a course dull and meaningless for the student.''

Background enrichment beyond the immediate needs for class instruction is given in some places in the TRB. An example occurs in Chapter 16, where the contribution of wave mechanics to our model of the atom is discussed ''although it would be undesirable to take it up in class.''

All of the references appearing at the ends of chapter in the text are repeated in the TRB (labelled T, for text) and additional references are given for background enrichment for the teachers. Suggestions are made for making effective use of the references. For example: ''The students may find it interesting to try to verify the entries in the table,'' and ''The textbook questions may help to lead the students along.''

The TRB includes three appendices. Appendix I deals with the Course Plan and comprises general advice, based on feedback, and a table of experiments indicating preferred methods for their administration and the time required for each.

Appendix II gives Additional Questions and Problems which may be used for homework or for examinations, with comments concerning their use. These are of four types: (1) essay questions; (2) double multiple-choice questions; (3) simple (single) multiple-choice questions; and (4) multiple-answer multiple-choice questions. Type 2 is a type, originated by a member of the staff (and we have since learned of independent origination elsewhere), in which each question has two multiple-choice parts: one in which the student chooses an answer to a question and the other in which he must choose the correct reason for having chosen that answer. Both parts must be correct. These are difficult to design. The TRB gives 39 of them. In Type 4, the multiple-answer multiple-choice question, the student chooses as many answers as he thinks correct (several answers are correct) and is penalized for wrong answers.

Appendix III deals with Film Evaluation. It lists 84 16-mm films and 64 8-mm film loops with full specifications, very brief content description, and evaluation with respect to appropriateness for PSNS, as well as information for obtaining them. This list is the result of a great many man-hours of effort. In addition to the reviewing of possibly useful films that was done by the whole staff on occasional afternoons during the summers of 1965-67, one of the staff members (S. Aronson) spent fulltime during the summer of 1968 viewing and evaluating films for use with the PSNS course and assembling the information presented in Appendix III.

Appendix IV is a Reference List, giving author, title, publisher and date of publication of all books referred to in the text and TRB.

D. THE ROLE OF THE ADVISORY BOARD

1. Personnel

The Advisory Board was established even before the project was funded. At the Latham meeting in September, 1964, the composition of the Board was determined. It was decided that the following groups should be represented on the board:

(1) The Advisory Council on College Chemistry

(2) The Commission on College Physics

(3) The New York State Department of Education

(4) A typical elementary school science curriculum developmnet project

(5) An industrial research laboratory dedicated to the science education of the public

(6) The PSNS staff (in the form of the Director and Associate Directors)

Appropriate individuals to fill these positions were identified and contacted by PSNS directors and CCP staff members. The first meeting occurred at the American Institute of Physics in New York in February, 1965, as part of a session where summer and other future activities were planned.

The original Advisory Board comprised the following individuals:

(1) Charles C. Price, Advisory Council on College Chemistry, and Department of Chemistry, University of Pennsylvania

(2) Robert Resnick, Commission on College Physics and Department of Physics, Rensselaer Polytechnic Institute

(3) Frank R. Kille, New York State Department of Education

(4) Arthur H. Livermore, American Association for the Advancement of Science (developers of Science, A Process Approach)

(5) Alan N. Holden, Bell Telephone Laboratories

(6) Lewis G. Bassett, PSNS Project Director and Department of Chemistry, Rensselaer Polytechnic Institute

(7) Robert L. Sells, PSNS Project Associate Director and Department of Physics, State University of New York College at Geneseo

(8) Elizabeth A. Wood, Chairman of the Advisory Board, PSNS Project Associate Director and Bell Telephone Laboratories

In the fall of 1966, Elizabeth Wood retired from Bell Telephone Laboratories and began preparations for an extended absence from the country. She therefore resigned as Chairman of the Advisory Board though she retained a seat on the Board and her role as Associate Project Director. Her position as Chairman of the Board was filled by A.A. Strassenburg, who had previously been associated with the project as a CCP staff member and who had moved to New York the previous summer. At the same time two other additions to the Board were made. Both of these individuals had shown great interest in the project and were effectively already serving in an advisory capacity. The three additions were as follows:

(9) A.A. Strassenburg, Chairman of the Advisory Board PSNS Project Associate Director, Department of Physics, State University of New York at Stony Brook, and American Institute of Physics

(10) Donald F. Holcomb, Department of Physics, Cornell University

(11) James H. Werntz, Department of Physics, University of Minnesota and Minnemast Curriculum Project

One more member was added to the Board in 1967. Professor Walter Eppenstein of the Physics Department at RPI had played a vital role during the summer of 1965 by arranging for working space for project staff members in the Science Center at RPI and by acting as

liaison between project personnel and campus employees responsible for needed services. He also had acquired valuable experience in the production of films and other visual aids during a year on the staff of Harvard Project Physics. It was therefore decided that our administrative and productive capacity would be strengthened by formalizing his relationship to the project and naming him Codirector. Thus the twelfth and final Board member appointed was:

(12) Walter E. Eppenstein, PSNS Project Codirector and Department of Physics, Rensselaer Polytechnic Institute

2. Meetings

The Advisory Board was first assembled on Feb 15 and 16, 1965 as part of a larger meeting involving the staff members already committed at that time. Since the project had not yet been funded, the Commission on College Physics sponsored this meeting. The primary concern was to identify talented staff members and to plan operational procedures for the summer working session. A report of this meeting exists, but because it is lengthy and records no crucial decisions, it is not included here.

After the grant was made, Board meetings were held at project expense once each summer at RPI and at least once each winter, usually at AIP headquarters in New York until April of 1969. So few decisions remained to be made after that time that no further meetings were held. There follows a list indicating the date and location of all PSNS Advisory Board Meetings.

(1) Feb 16, 1965: AIP and the Biltmore, New York

(2) Aug 2, 1965: RPI, Troy

(3) Nov 26-27, 1965: AIP, New York

(4) Mar 11-12, 1966: AIP, New York

(5) Aug 8 and 9, 1966: RPI, Troy

(6) Feb 20-21, 1967: AIP, New York

(7) Aug 1, 1967: RPI, Troy

(8) Mar 8, 1968: The Biltmore, New York

(9) Jul 31-Aug 1, 1968: RPI, Troy

(10) Apr 11, 1969: The Holiday Inn, Troy

Reports of the winter meetings exist; copies of the reports for meetings (3), (4), (6), and (10) are included as Appendix D-1. Since project directors, including the Advisory Board Chairman, were completely immersed in materials production during summers, no reports of any of the summer meetings were prepared.

3. Advisory Board Advice

The PSNS directors believe that the Advisory Board was exceptionally valuable to them. Members were selected because of their special interests and experiences relevant to the project. As a result, attendance at meetings was high (seldom more than one or two members missing). The Board kept well informed on progress in materials development and participated vigorously in policy decisions. The directors sought advice of individual Board members often in between meetings and frequently put important matters to a vote at meetings. The ways in which the Board advised us on various issues are enumerated below:

(1) The Board criticized the choice and treatment of topics included in the course materials.

(2) They recommended that we not undertake the production of films, and we did not.

(3) They suggested that we view existing films and advise teachers on which are most suitable for use with PSNS; this stimulated an extensive film review effort which resulted in the film evaluations contained in Appendix III to the Teachers' Resource Book.

(4) Discussion on supplementary chapters was frequent and heated. Some Board members felt we should produce many supplementary chapters to add flexibility to the course; a majority felt we should produce few so as not to encourage an emphasis on wide coverage. We ultimately limited production to five. The Board decided on which of many proposed titles should be developed and completed.

(5) The Board guided us in designing the collection and use of feedback.

(6) They urged us to limit sharply the number of trial schools during the first two years so that we could maintain close contact with each trial teacher and provide materials free of charge.

(7) They made the final selection of trial schools for 1966-67 from among those that applied.

(8) They supported our inclination to put our efforts into materials development at the expense of public relations, but did advise the publication of annual newsletters.

(9) They were consulted whenever new staff was sought.

(10) They recommended at an early meeting that we locate promptly a commercial-apparatus supplier to help develop, stock, and ship apparatus; Damon was asked to assume these responsibilities during

the second year of the project.

(11) They advised that the involvement of a commercial publisher be delayed until after two preliminary editions had received adequate trial; this advice was followed exactly.

(12) When bids from publishers were invited, several Board members helped evaluate proposals and by vote narrowed the field of candidates from eight to four. Five Board members interviewed representatives from four finalists and by vote decided to negotiate with Wiley.

(13) The Board frequently discussed the training of prospective PSNS teachers and urged us to arrange for PSNS summer institutes; two Summer Institutes were held at RPI (see Section E-1b).

(14) When contact with institute participants revealed that knowledge of PSNS was not widespread, the Board advised us to distribute widely a special communication announcing the availability of PSNS materials in third preliminary edition; this was done.

(15) During the last two years of the project, the Board encouraged us to invest time and money in short workshops for prospective teachers; this was done (see Section E-1c).

(16) At the request of the publisher, the Board discussed the suitability of PSNS for high school use. They ultimately approved a statement drafted by the Board Chairman (see Appendix D-2).

(17) The Board assisted us in the preparation of renewal proposals to the NSF.

(18) Evaluation was discussed extensively at many meetings. While several members were negative toward evaluation, the majority supported the final actions taken (see Section E-3).

It is clear from the foregoing record that the Board exerted extensive influence on decisions made by project directors. Representation from several sectors of the scientific community provided a variety of viewpoints and experiences to draw upon. Even more important was the fact that our Board members were persuaded of the importance of this project and they participated vigorously whenever asked to deliberate on matters of consequence.

E. SPECIAL PROJECTS

The PSNS directors and staff undertook a number of special projects which fall in one of the following three categories: (1) communication with prospective teachers of PSNS; (2) communication with science educators generally; (3) evaluation of the impact of PSNS on students. These efforts will be described below.

1. Communication With Prospective Teachers of PSNS

a. Briefing Session, Aug 22 to Sep 2, 1966

The eight teachers who experimented with the first preliminary edition of PSNS during academic year 1965-66 were either project staff members or friends of staff members. Materials and suggestions on teaching techniques were supplied directly to the teachers by the project directors, and feedback from the trial teachers was provided through frequent and direct letters and phone calls. It was possible to maintain such close contacts as long as the number of teachers was small. In 1966-67 the number of trial teachers increased to 23, and more effective mechanisms were needed to provide assistance to the teachers and to insure their cooperation in sharing classroom experiences which would influence future revisions of materials.

It was decided in the spring of 1966 to invite applications from teachers who wished to offer the PSNS course during the following academic year and to cooperate with project staff in the improvement of the course. Those 23 teachers whose applications were accepted were expected to provide feedback through several mechanisms in exchange for receiving free materials and other forms of assistance. (Feedback is discussed in Section C of this report.) One important

form of assistance provided was a two-week briefing session held at RPI late in the summer of 1966. A.A. Strassenburg was in charge of this session.

Various techniques were used in an effort to convey a sense of the PSNS philosophy and to suggest teaching styles which would contribute toward the achievement of course goals:

(1) Teachers were assigned portions of the text to read and questions in the text to answer. Classes were then conducted by Strassenburg, Wood, and others during which concepts introduced and questions posed in the text were discussed in the open-ended, student-centered style characteristic of PSNS.

(2) Many of the experiments described in the text were performed by the teachers. For each experiment a pre-lab discussion was conducted to identify the goals of the experiment and to preview special techniques which might be needed to overcome experimental difficulties. Post-lab discussions are regarded as even more important by the course developers; it was during these sessions that the trial teachers were hopefully convinced that students must draw their own conclusions from experimental results, and not be told what results to expect.

(3) The trial teachers were asked to write questions appropriate for an examination on specific portions of the PSNS materials. Examinations were then constructed from these questions and administered to the teachers. After taking an examination, the teachers criticized it, item by item. This

was a devastating but instructive experience. Hardly a single question escaped a label of ''ambiguous'' or ''inappropriate for PSNS.'' We learned that the construction of examinations was the weakest aspect in the performance of most of these teachers, and also that it provided an excellent vehicle for conveying our ideas concerning learning objectives.

(4) Considerable attention was given to ancillary teaching aids such as paperback books and films. Some films were shown and analyzed for their usefulness in conveying concepts relevant to PSNS. We also profited by drawing on the collective experience of the group with a variety of other texts and references.

In addition to the main goal of transmitting to the trial teachers understanding of PSNS objectives and competence in using PSNS materials, two other useful results were accomplished during the briefing session. First, the teachers discovered who on the project staff could be helpful with various kinds of problems and they established contacts which eased later communications. Second, a spirit of friendship and interest in the success of a common endeavor developed which must surely have improved the quality of teaching and feedback offered by the briefing session participants. A report of this briefing session was included in Newsletter No. 2 (see Appendix E-3).

b. Summer Institutes

The PSNS directors recognized that briefing sessions such as the one discussed in the previous section would become too expensive and too time consuming as the number of teachers planning to adopt the

PSNS course increased. It was decided that efforts should be made to initiate a program of summer institutes to accommodate teachers in need of orientation to the PSNS philosophy and materials - particularly those with weak backgrounds in chemistry or physics. Clearly the staff for such an institute must be thoroughly familiar with PSNS. During the years of course development, only PSNS staff members qualified, and these were all occupied at RPI developing materials each summer. It was therefore decided that the first few institutes should be held at RPI and conducted by PSNS staff members. In later years, efforts were made to stimulate other scientists with experience using PSNS materials to submit proposals for holding institutes on their own campuses. The following paragraphs summarize the extent of these efforts and the nature of the three completed institutes which were devoted primarily to an examination of the PSNS course.

(1) 1967

An eight-week institute was held at RPI during the summer of 1967. Stanley Bunce and A.A. Strassenburg served as codirectors. Forty college teachers of physical science at two-year and four-year colleges participated. Most of these held master's degrees in physics, chemistry, or science education; a few held the Ph. D. Support was provided by the National Science Foundation under a separate grant.

The program consisted of three parts. During the first half of each morning, all participants performed and discussed selected experiments described in the PSNS text, An Approach to

Physical Science (the second preliminary edition was in use at that time). Following a coffee break about midmorning, the group divided into two classes roughly equal in size. One class, consisting of teachers weak in chemistry,was taught chemistry at the freshman college level (from the text by Bassett, Bunce, Clark, Carter, and Hollinger) by Stanley Bunce and Wilfred Campbell of RPI. The other class, selected for its need of physics instruction, studied physics (using the elementary college texts by Weidner and Sells) from A.A. Strassenburg, SUNY-Stony Brook, and Robert Sells, SUNY-Geneseo.

The third period of each day (early afternoon) was devoted to an examination of various teaching aids suitable for use with PSNS and other physical science courses. The viewing of films occupied much of the time, but other visual aids were also displayed. Demonstrations whic. exhibit the use of simple apparatus were performed. The examination of remedial math programmed materials (e.g., the work of H.R. Crane) and student difficulties with quantitative aspects of the chemistry and physics courses led to a series of lessons on elementary mathematical techniques offered by A.A. Strassenburg. The participants were encouraged to browse through a library of physical science texts and paperbacks on science during the later afternoon hours. The following scientists contributed as guest lecturers:

Elizabeth Wood, PSNS Project
James Werntz, University of Minnesota
H.R. Crane, University of Michigan
Alan Holden, Bell Telephone Laboratories

(2) 1968

The institute program described immediately above was repeated during the summer of 1968 but with a few changes. Henry Hollinger, RPI chemist, was added to the instructional staff. Stuart Whitcomb, Earlham College, replaced Robert Sells on the instructional staff. The program was altered as follows:

(a) The period devoted to PSNS materials was split into two parts. All PSNS experiments (as described in the third preliminary edition) were performed during the early morning periods. The late morning periods were devoted to post-lab discussions, discussions of the questions in the text, and study of the newly available Teachers' Resource Book.

(b) The chemistry and physics classes were shifted to early afternoons.

(c) The late afternoons were devoted to films on two days a week, a mathematics review session one day a week, and left open the other two days.

(d) The guest lecturers were as follows:

Elizabeth Wood, PSNS Project
Charles Price, University of Pennsylvania
Arthur Livermore, AAAS
Donald Holcomb, Cornell University

A report on this institute prepared for the Institutes Section of NSF is included in Appendix E-1.

(3) 1969

Proposals for PSNS institutes to be held during the summer of 1969 were submitted from the following institutions

and directors:

Wheaton College, Norton, Massachusetts,
H.M. Landis

Oxford College for Women, Miami, Ohio,
Richard Sakurai

University of Washington and the Pacific Northwest Association of College Physicists,
Wilbur Johnson

None of these proposals resulted in a grant.

(4) 1970

Proposals for PSNS institutes to be held during the summer of 1970 were submitted from the following institutions and directors:

Federal City College and American University,
Mary Lynn Bolton and Leo Schubert

Earlham College, Richmond, Indiana,
Stuart Whitcomb

Southern Oregon College, Ashland, Oregon,
Stuart Inglis

Only the Earlham proposal resulted in a grant. The report of this institute is included in Appendix E-1.

(5) 1971

Proposals for PSNS institutes to be held during the summer of 1971 have been submitted from the following institutions and directors:

Earlham College, Richmond, Indiana,
Stuart Whitcomb

Green Mountain College, Poultney, Vermont,
Lawrence Boothby

The fate of these two proposals is not yet known.

c. Workshops

The program of summer institutes described above provided adequate preparation for the participants who were prospective teachers of PSNS, but the number of teachers accommodated each year did not begin to meet the demand. The project directors therefore decided to initiate a program of workshops through which a larger number of teachers would have opportunities to become familiar with PSNS materials. Three types of workshops were planned:

(1) One session, one or two hours in length, at which a PSNS staff member would demonstrate PSNS apparatus, lead the audience in doing chair-arm experiments, and distribute written course materials and promotional literature. We imagined these would normally take place as part of the program of a larger meeting on science teaching such as a regional NSTA meeting or a meeting of a state academy of science.

(2) One-day meetings of 15-75 teachers from neighboring colleges, gathered together on a Saturday (or another holiday from classes) expressly to learn about PSNS. Laboratory experiments and classroom discussions which illustrate PSNS techniques would be scheduled.

(3) Two-day meetings of teachers living in thinly populated regions where great travel distances make it difficult to bring science teachers together for shorter meetings. At these, teachers could perform PSNS experiments and discuss thoroughly the philosophy of the course.

Workshops of types (1) and (2) were arranged. During academic year 1968-69 the costs were borne entirely by the publishers, John Wiley and Sons. Beginning with September, 1969 the costs were shared between Wiley and PSNS; Wiley paid participant expenses and supplied PSNS materials free while PSNS paid travel and consulting fees to the PSNS staff members who conducted the workshops. The availability of these sessions was announced in numerous communications; Wiley salesmen also helped to generate interest in and to schedule workshops. Lewis Bassett, A.A. Strassenburg, Elizabeth Wood, and Gene Davenport of Wiley all contributed to the scheduling of and arrangements for workshops.

The ground rules which indicate what a group must do to qualify for a visit and some of the procedures involved in arranging and conducting a workshop are listed below:

(1) Applicants must guarantee a minimum attendance which includes either 30 college science teacher participants or representatives from 10 different colleges.

(2) Any accredited two-year college, four-year college, or university which does teach or is planning to teach a physical science course for nonscience students is eligible to apply.

(3) A host institution must be able to provide:

(a) a classroom with chair-arm seats or tables,

(b) several tables on which the staff consultant can display apparatus and perform demonstrations,

(c) a. c. power outlets and a supply of water,

(d) an overhead projector and a 35-mm slide projector,

(e) a separate location for a coffee break and coffee for the participants,

(f) meal facilities as required,

(g) overnight accommodations when necessary,

(4) Meetings - except for type (1) meetings - should not be scheduled for less than six hours exclusive of meal functions. When travel distances are small, as in urban areas, one-day meetings are reasonable; when travel distances are large, two-day meetings should be considered.

There follows a list indicating: the time and place of each workshop held before Sep 1, 1970 (and two scheduled for October); the host individual and his group or institution; the approximate attendance; and the PSNS staff member who conducted the session.

Date and Location	Host	No.of Participants	Workshop Leader
Sep 28,1968 Salina, Kansas	Kansas State Dept. of Public Instruction	25	A.A.Strassenburg
Jan 19,1969 Berea, Kentucky	Thomas Strickler, Berea College	30	E.A. Wood
Mar 14,1969 Dallas, Texas	NSTA Regional Meeting	50	S.J. Inglis
Mar 15,1969 Chicago, Ill.	Edwin DeYoung, Loop College	40	A.A.Strassenburg
Apr 12,1969 College Park,Md.	Chesapeake Physics Association	40	E.A.Wood
Apr 18,1969 Des Moines,Iowa	David Robinson, Drake University	25	A.A.Strassenburg and E.L.Carlyon

Date and Location	Host	No.of Participants	Workshop Leader
Apr 19,1969 Kirksville, Mo.	John Settlage, N.E.Mo. State College	27	A.A.Strassenburg and E.L.Carlyon
Apr 25,1969 Richmond, Ind.	Indiana Section of the AAPT	45	S.E.Whitcomb
May 7,1969 Corning, N.Y.	College of the Finger Lakes Region	25	E.A.Wood
May 10,1969 New Brunswick,N.J.	Rutgers University	35	E.A.Wood
Oct 31,1969 Los Angeles,Calif.	NSTA Regional Meeting	50	S.J.Inglis
Dec 5,1969 Biloxi, Miss.	NSTA Regional Meeting	12	H.B.Hollinger
Feb 7,1970 Kiamesha Lake,N.Y.	New York State Teachers Association	10	E.A.Wood
Mar 13,1970 Cincinnati,Ohio	National NSTA Meeting	100	S.E.Whitcomb
Mar 14,1970 Houston,Texas	F-ank Price, South ..xas Junior College	24	S.J.Inglis
Mar 21,1970 Buffalo,N.Y.	John Barnett, SUNY College at Buffalo	70	A.A.Strassenburg
Apr 11,1970 Monroe, La.	Clyde Combs,Jr., N.E.La. State College	25	E.L.Carlyon
Apr 25,1970 Portland,Oregon	Bruce Kaiser, Portland State University	40	S.J.Inglis
May 2,1970 Bowling Green,Ohio	Prof. Shirkey, Bowling Green State College	30	H.B. [illegible]linger
May 23,1970 Carbondale,Ill.	J. Sullivan, Southern Illinois University	30	S.E.Whitcomb
Jun 6,1970 Columbus,Ohio	Two-year College Chemistry Council	30	S.E.Whitcomb
Oct 9,1970 Grand Rapids,Mich.	NSTA Regional Conference	30	S.E.Whitcomb
Oct 23,1970 Manhattan,Kansas	Consortium for the Advancement of Physics Education	150	A.A.Strassenburg

Sample reports prepared by the workshop leaders are appended (see Appendix E-2.

2. Communication With the General Science Community

The PSNS staff was quite small and tended to concentrate on materials development; we rarely devoted much time to seeking publicity. Nevertheless, some efforts were made to keep the science community informed of our progress. These efforts took the form of occasional newsletters sent to a growing mailing list of interested science teachers, infrequent talks at society meetings, and articles in professional journals. The following paragraphs summarize these activities.

a. Newsletters

Once each winter a newsletter was produced and sent to everyone included on the project mailing list. (The mailing list consisted of the names and addresses of all individuals who exhibited any interest in the project; it included, for example, all those who wrote any project director for information. There are about 1500 names on the list.) The newsletters described the philosophy of the course, reported on the status of materials under development and how they could be obtained, and listed those who contributed to the project in significant ways. The four newsletters are included with this report as part of Appendix E-3.

During the spring of 1967 a special communication was prepared and sent to a much larger number of science teachers. We were at that time beginning work on the third preliminary edition of the text, an edition which would be published by Wiley and would serve

for two academic years while the final edition was in production. It was planned that Wiley would also process orders for equipment required for experiments described in the third edition. We anticipated substantial demand for materials during the academic years 1967-68 and 1968-69. We realized we would not be able to screen potential users, brief those selected, and collect feedback systematically from them, as we did in 1966-67, if the number of users was allowed to grow. After careful consideration we agreed that the course would sell itself and be sold by the publishers, and that teachers would ultimately have to learn to use it without direct assistance from the staff, so we decided to abandon user control immediately. This decision left us with the problem of determining how many third-edition texts and how much associated apparatus should be stocked for the coming two years. The special communication was designed to provide this information. A question was also asked about the interest in PSNS summer institutes.

The document prepared was entitled "An Approach to Physical Science - Announcing the Release of Materials Produced by the PSNS Project for a College Course in Physical Science for Nonscience Students." It was distributed to physics and chemistry department chairmen in every college in the U.S. where, in our judgment, a physical science course for nonscience students would be offered. A copy of this document is included as part of Appendix E-3.

b. Talks and Articles

From time to time during the lifetime of the project the directors and certain staff members have been asked to present talks

about PSNS at meetings of science educators, or to prepare articles for publication in newsletters and journals. (These talks are distinct from workshops in that the audience is not involved in working with the course materials.) The project directors did not deliberately arrange for these, and no coordinated effort was made to publicize the course in this way. We did accept most invitations and we suggested other staff members when the one invited could not accept. Each speaker prepared his or her own presentation, and no spec'al efforts were made to assemble visual aids for this purpose. When major articles were prepared for publication, they were generally reviewed by all the directors prior to submission.

Mcre attention to effective public relations might have been beneficial; thc policy adopted, however, suited the schedules and the sense of priorities of the directors. We do feel that the project profited from the opportunities it was offered to publicize its products.

There follows a list of talks given by directors and staff members during the past five years. The list indicates dates and locations, the organization sponsoring the meeting, and the name of the speaker.

Talks on PSNS by Staff Members

Date and Location	Occasion	Speaker
Oct 1965 Chicago,Ill.	Regional Meeting, NSTA	R.S.Sakurai
Jan 29,1966 New York,N.Y.	American Association of Physics Teachers	E.A.Wood
Mar 6,1966 Greensburg,Pa.	Pennsylvania Catholic Science Round Table, Seton Hill College	L.G.Bassett
Sep 1,1966 Chicago, Ill.	National Science Teachers Association	E.A.Wood
Oct 20,1966 Minneapolis,Minn.	Minnemast Staff,University of Minnesota	E.A.Wood
Feb 1967 New York,N.Y.	New York Association TYCPT	Shirley Aronson
Feb 6,1967	American Chemical Society	A.A.Strassenburg
Apr 14,1967 Portland, Ore.	PNACP	S.J.Inglis
Jun 1967 Garden City,N.Y.	Nassau Community College Engnr.	Shirley Aronson
Jun 1,1967 New York, N.Y.	Brooklyn Catholic Dioceses	A.A.Strassenburg
Oct 6,1967 Boston, Mass.	National Science Teachers Association	S.J.Inglis
Nov 4,1967 Cincinnati,Ohio	National Science Teachers Association	S.J.Inglis
Nov 10,1967 Atlantic City,N.J.	New Jersey Science Teachers Association	A.A.Strassenburg
Mar 30,1968 Washington,D.C.	National Science Teachers Association	S.J.Inglis
Apr 1,1968 San Francisco,Calif.	American Chemical Society	E.A.Wood
Apr 26,1968 Seattle, Wash.	University of Washington	E.A.Wood

Date and Location	Occasion	Speaker
Apr 26,1968 San Juan, P.R.	PRSTA	S.J.Inglis
Apr 27,1968 Muncie, Ind.	Indiana Sect. AAPT	S.Whitcomb
Sep 14,1968 Montauk, N.Y.	Wiley Teachers' Conference	A.A.Strassenburg
Sep 28,1968 Salina, Kansas	KSTA	A.A.Strassenburg
Oct 1968 Jefferson City,Mo.	Missouri Association of Jr. Colleges	R.S. Sakurai
Oct 11,1968 Portland, Oregon	National Science Teachers Association	S.J.Inglis
Nov 23,1968 Atlanta, Ga.	Int'l. Services to Education	A.A.Strassenburg
Dec 11,1968 New Brunswick,N.J.	New Jersey Section of AAPT	E.A.Wood
Feb 1969 New York, N.Y.	American Association of Physics Teachers	Shirley Aronson
Mar 5,1969 Institute,W.Va.	W.Va. State College	R.L.Sells
Mar 13,1969 Farmingdale,N.J.	SUNY Agricultural and Federal State College	E.A.Wood
Apr 12,1969 College Park,Md.	Chesapeake Physics Ass'n. University of Maryland	E.A.Wood
Apr 25,1969 Richmond, Ind.	Indiana Section AAPT	S.Whitcomb
May 10,1969 New Brunswick,N.J.	Rutgers University	E.A.Wood
Oct 31,1969 Los Angeles,Calif.	National Science Teachers Association	S.J.Inglis
Nov 7,1969 Atlantic City,N.J.	New Jersey Science Teachers Association	E.A.Wood

Date and Location	Occasion	Speaker
Feb 5,1970 Boston,Mass.	Schools of Education and Science Seminar, Boston University	L.G.Bassett and E.L. Carlyon
Feb 9,1970 New York, N.Y.	Teachers Education Conference New York University	A.A.Strassenburg
Feb 13,1970 Washington,D.C.	NSF Coord. Conf.	A.A.Strassenburg
Mar 13,1970 Buffalo,N.Y.	PSNS WorkShop, Buffalo State University	A.A.Strassnburg
Mar 13,1970 Cincinnati,Ohio	National Science Teachers Association	S.Whitcomb
Mar 14,1970 Houston,Texas	PSNS Workshop	S.J.Inglis
Apr 18,1970 Saratoga,Calif.	California Association of Chemistry Teachers	S.J.Inglis
Apr 25,1970 Portland, Oregon	PSNS Workshop	S.J.Inglis
May 23,1970 Carbondale,Ill.	Workshop at SIU	S.Whitcomb
Jun 4,1970 Columbus, Ohio	Two-Year College Chemistry Conference	S.Whitcomb
Jul 30,1970 Richmond, Ind.	PSNS Institute, Earlham College.	A.A.Strassenburg
Oct 9,1970 Grand Rapids,Mich.	NSTA Great Lakes Region	S.Whitcomb
Nov 13,1970 San Francisco,Calif.	National Science Teachers Association	S.J.Inglis

The list below includes the major articles about PSNS written by staff members and published in science journals and newsletters:

(1) Report of a Conference on Physical Science Courses, CCP Staff, American Journal of Physics, Vol. 2, No.6, pp.428-432, June, 1964

(2) PSNS Project at RPI, E.A.Wood, American Journal of Physics, Vol. 34, Part 2, No.9, pp.891-894, September, 1966.

(3) Physical Science for Nonscientists, PSNS Staff, Physics Today, Vol. 20, no. 3, March, 1967.

(4) Physical Science for Nonscience Students, E.A.Wood, Commission on College Physics Newsletter, No.17, October, 1968.

(5) The PSNS Project, E.A.Wood, Journal of Chemical Education, Vol. 46, p. 69, February, 1969.

(6) PSNS, AIP Staff, AIP Educational Newsletter, Vol. XII, No. 8, November, 1969.

(7) PSNS, A.A. Strassenburg, Seventh Report of the International Clearinghouse on Science and Mathematics Curriculum Developments, 1970 Edition, pp.486-488.

Number (1) is a report of the Chicago conference sponsored by CCP which led directly to the organization of PSNS (see Appendix A-1). Number (2) was part of the biannual CCP report. Number (4) was reproduced in sufficient numbers so that it could be distributed by Wiley along with other promotional literature about PSNS materials. Number (7) is not a publication in a traditional sense, but this reference contains much information about the project. Numbers (2) through (6) appear in this report as Appendix E-4.

3. Evaluation

a. Evaluation of Student Performance

The project staff spent relatively little time, compared to other course development projects, on the development of instruments

for the evaluation of performances of students enrolled in the course. Some sample test items are included in the Teachers' Resource Book, but these are meant to provide only a flavor for the style of examination questions thought suitable by the project staff; there are not enough items to allow a teacher to assemble even one complete exam on any one unit of the book. The project directors felt strongly that multiple-choice questions, or other styles of highly objective questions, are compatible with the PSNS course only if very carefully designed. Usually essay questions or other open-ended styles of questions would be preferred. Once this is understood, it seems clear that the questions should be designed by the instructor to match the abilities and numbers of his students and the kinds of experiences he has provided for them.

Two of our staff members, Richard Sakurai and H.M. Landis, developed a double multiple-choice question style which seems promising as an objective method of evaluating PSNS students. The first half of the question requires a choice among possible factual answers; the second half requires a choice among reasons for selecting the first answer. A paper describing this technique was submitted for publication in the American Journal of Physics.

b. Evaluation of Progress During Course Development

The primary method of determining whether or not the materials developed were satisfactory involved the collection of feedback from teachers using the preliminary versions of the materials. This feedback came in three forms: unsolicited testimonials, written reports, and oral reviews.

The early testimonials from the trial teachers were almost uniformly favorable. While the project directors did not place too much importance on these -- since most of the early teachers were also closely connected to the development efforts -- nevertheless they found great encouragement from them. The only negative reports during the first two years came from a teacher with a very large class (over 800 students), a staff member who was required to use a conventional lecture course with thw PSNS laboratory, and a teacher who had selected only students of high academic standing.

The eight trial teachers during 1965-66 and the 23 trial teachers during 1966-67 provided written records of their classroom and laboratory experiences. A sample report form is appended (see Appendix E-5). These teachers were also assembled, together with project staff, for short meetings once during each academic year and for a week at the beginning of each summer writing session. Page-by-page criticism was elicited from the teachers at these meetings. The entire process of collecting feedback and feeding it back into the developmental activities is discussed in more detail in Section C of this report.

c. Summative Evaluation of Success in Achieving Course Objectives

A major criticism of the original proposal made by reviewers focused on the lack of any plan for evaluation. The project directors took this criticism seriously, and discussions about evaluation occupied many hours at meetings of the Advisory Board. Our stated objectives (see Table 3 in the first paper in Appendix E-6) called

for changes in student attitudes and growth in science process skills. Several Board members felt that the former could not be evaluated, and the latter could be measured through course exams. Therefore they argued against a formal evaluation performed by external evaluators. The majority felt that science teachers only measure acquisition of knowledge with course exams and thus any hope of measuring affective variables lay with professional evaluators. Therefore the project directors began to negotiate with educational-measurement experts.

During 1966-67, E.A. Wood and A.A. Strassenburg paid several visits to the offices of Educational Testing Service in Princeton, New Jersey. These negotiations proceeded slowly at first, in part because a common language for effective communication between evaluators and scientists had to be discovered, and in part because new measurement experts became involved in the task on each visit. In the fall of 1967, Stanley Zdep of ETS was assigned to PSNS. Stuart Inglis, then working fulltime for PSNS, cooperated closely with him and some progress on evaluation was made. An evaluation design was submitted by Zdep and approved by the PSNS Advisory Board. It called for the development of a new evaluation instrument by ETS. Part of the validation process called for PSNS to arrange for the administration of preliminary versions of the instrument to both science and nonscience majors at a number of colleges. These trials were held during the winter of 1967-68. ETS then generated a revised evaluation instrument and submitted it to PSNS for approval. The Advisory Board refused to approve it and asserted that the ETS evaluators had failed

to understand the real intent behind the PSNS objectives. The project directors then invited ETS to send two evaluators to RPI (at PSNS expense) to interact with project staff for two weeks during the summer writing session. ETS refused this invitation. As a result, the Advisory Board decided at their summer meeting in 1968 that we should sever our relationship with ETS and seek another evaluator. This was done by letter from A.A. Strassenburg to Stanley Zdep dated October 14, 1968 (a copy was sent to Alfred Borg at NSF). As the letter points out, some expenses had been incurred by ETS for services performed; these were paid by PSNS.

In the fall of 1968, Wood and Strassenburg began negotiations with Mrs. Hulda Grobman concerning PSNS evaluation. Mrs. Grobman did study the PSNS objectives and materials, and wrote a brief evaluation proposal. Strassenburg found this promising, but not sufficiently detailed and defective in some respects. He requested some elaboration and fortification of the evaluation design. Mrs. Grobman chose to withdraw from the project rather than prepare another proposal. Thus on Jan 20, 1969, we had no immediate prospects for an evaluation.

At the spring meeting of the Advisory Board it was decided to request an extension of the project termination date to allow time to complete supplementary chapters in progress and a course evaluation. A.A. Strassenburg had visited Wayne Welch at Harvard and had invited him to prepare an evaluation proposal. Welch did so and presented this proposal to the Board at a meeting in Troy on Apr 11, 1969. The Board voted to accept this proposal and Welch was notified that he

should begin work at once. His efforts have led to what we feel is a well-planned and satisfactory evaluation study. Two reports prepared by Dr. Welch, one describing the research designed, and the other reporting the results are included as Appendix E-6. For a report on the cost of this evaluation, see Section B of this report.

Although the design of the evaluation program and the conclusions drawn from it can only be interpreted and understood by a careful reading of the articles in Appendix E-6, an outline summary of the program, prepared by Dr. Welch, is helpful at this point.

SUMMARY OF THE EVALUATION RESULTS AS REPORTED IN APPENDIX E-6

Part I. Strategy and Implementation

1. Evaluation of a national curriculum project in a dozen colleges and universities involving more than 1,000 students was successfully conducted due to the fine cooperation received from the cooperating instructors.

2. College students were generally cooperative in evaluating college courses.

3. There was considerable attrition of students enrolled in physical science courses during the course. The decline in PSNS was 29 per cent while in other courses it was 37 per cent.

Part II. Results

4. Students enrolled in physical science courses in college are generally freshmen and sophomores who bring with them typical high school experiences in science and mathematics. Nearly all have taken biology, about half have had chemistry and one in five has taken high school physics. Most have had two or more years of mathematics.

5. Physical science students score above average normative data on measures of interest in physical science, but are below average on mathematics interest.

6. There was an overall measured effect of the PSNS course on a set of 14 testing instruments. PSNS students had more positive attitudes and interest in science upon completion of the course than did students in other physical science courses.

7. Differences between the courses on measures of science process understanding were not statistically different.

8. The one negative result for the PSNS course compared to others, was a significantly lower score on the scale Doing Laboratory Experiments, Safe.

9. Regardless of the physical science course taken, students enrolled for one year rather than one semester showed significantly higher scores on measures of science process understanding and attitudes toward science.

10. Interviewed instructors expressed positive reaction to the course in general, and were enthusiastic in their judgment of its success.

11. The PSNS seemed to work best, that is, achieve its objectives when taught in a self-contained classroom with laboratory opportunities, discussion, and lecture occurring as the situation demanded.

12. The most pressing difficulty encountered by the instructors was the difficulty in obtaining manufactured laboratory and demonstration apparatus.

13. Another often expressed problem was the increased amounts of preparation time required on the part of the teachers.

14. Student reaction to the PSNS course was generally positive, particularly student interest. The most often voiced negative remark was the concern over the limited subject matter covered.

d. Independent Evaluation Efforts

PSNS has provided at least two graduate students with thesis topics in educational measurement. One of these was Handley Diehl, a PSNS staff member during the summer of 1965. In the winter of 1965-66, Diehl requested permission to teach PSNS under controlled conditions at Miami University (Oxford, Ohio) as part of his doctoral dissertation.

The PSNS Advisory Board granted permission but asked that he submit his thesis for review by the Board before releasing the data. A thesis was written, but the research results were never submitted to the Board. Presumably the thesis is available from Miami University.

The second student was George Frangos who taught a modified version of PSNS at California State College, California, Pennsylvania, and conducted research on the effects of this course on "student understanding of the scientific enterprise, understanding of solid matter and the techniques for its investigation, and the ability to do critical thinking." This work was part of a doctoral dissertation to be submitted to Ohio State University. In the spring of 1969 Frangos asked project staff members to criticize an evaluation instrument he had designed. He did receive substantial criticism and was advised that his modification - largely amounting to more material and an increased pace - altered the course so substantially that he was not really testing PSNS as originally designed.

Finally, it is worth mentioning that the publisher, John Wiley and Sons, hired a consultant to evaluate the possibility of preparing detailed learning objectives for PSNS with a view toward modifying the course materials to include a more extensive use of audio-visual aids. Bill Aldridge of Florissant Valley Community College reported in July 1969 that such adaptation is possible, but he was otherwise quite critical of the course materials.

e. Usage of the Course

The first preliminary edition of the course materials was used at eight colleges in 1965-66. Six of the instructors were PSNS staff members; the other two were in close communication with the staff (and one later became a staff member). Class sizes were small except at Ball State University where over 800 were enrolled in the course.

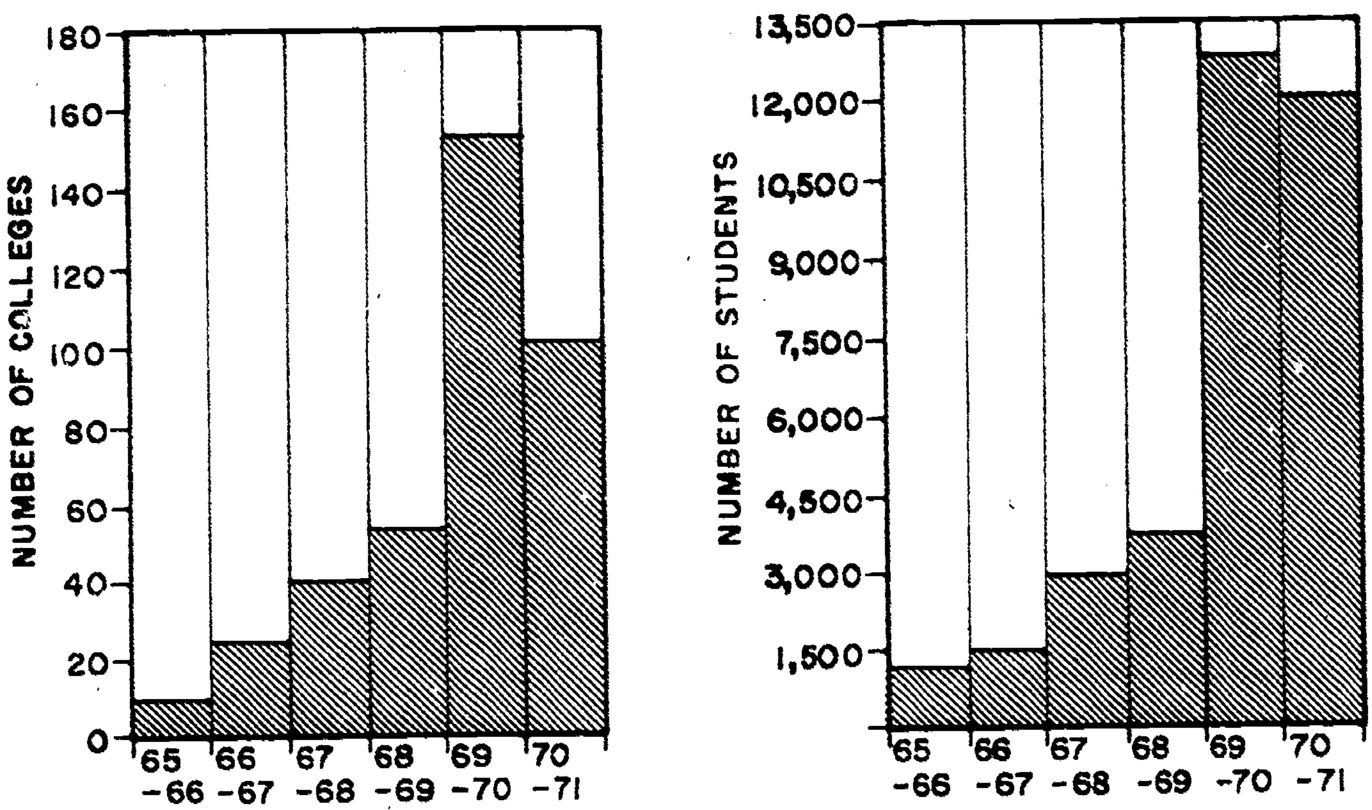
The second preliminary edition was used at 23 colleges during 1966-67. These had all applied for the opportunity to cooperate with the project; the instructors provided feedback on their experiences with the materials. On page 11 of Newsletter Number 2 (see Appendix E-3) is a list of the trial schools and the number of students enrolled at each. Enrollments varied between 10 and 150 students per college and total 1490 for an average of 65 students per college.

The third preliminary edition was used at approximately 40 colleges during 1967-68 and 50 during 1968-69. The only records concerning these schools were kept by Wiley, and from these records it is not easy to determine how many institutions had actually adopted the materials and how many had placed small orders for purposes of examination. It is known that a first printing of 5000 copies of Volume 1 sold out completely and a second printing was necessary.

The final edition of the text first appeared in January, 1969. The first version of the Teachers' Resource Book published by Wiley became available shortly thereafter. Apparatus for all the experiments described in the text, though provided by Damon Educational Incorporated, could be ordered along with books from Wiley. Sales

for 1969-70 were approximately 13,000 copies; 153 different colleges placed orders ranging from 10 to 612 copies.

During the summer of 1970 a volume containing five supplementary chapters was released and a new version of the Teachers' Resource Book, which included material on the supplementary chapters, became available. It is too early to report total usage for 1970-71, but the publishers anticipate sales similar to the previous year even though spring and early summer book orders from academic institutions are less than usual throughout the profession.



(a) Annual Numbers of Colleges Using PSNS

Figure E-1

(b) Annual Numbers of Students Using PSNS

APPENDIX A-1

The Chicago Conference

Sep 5-7, 1963

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APPENDIX A-2

The Rosemont Conference

Oct 18-19,1963

Report

of

New York-Pennsylvania Conference on Physical Science Courses

On September 5, 6, and 7, 1963, a conference was held at the Center for Continuing Education of the University of Chicago to stimulate activity among scientists and educators toward the development of materials for new and improved physical science courses for nonscience majors. The report of that conference contains the recommendation that several separate efforts be made to produce one-year elementary level college courses which combine chemistry and physics. Some general characteristics desirable for such a course were also outlined in the report.

The Chicago Conference succeeded in convincing a number of scientists and educators of the need for action. The most prompt response came from the New York-Pennsylvania area. Several physicists and chemists from major institutions agreed to contribute to the organization of a working group whose function will be to prepare new materials, try them in the classroom, and revise them in the light of the trial use. In order to aid the organizers in their search for persons in the area with the interest and ability needed to make significant contributions to the project, the Commission on College Physics and the Advisory Council on College Chemistry called a follow-up conference which was held at Rosemont, Pennsylvania on October 18 and 19, 1963.

The Rosemont Conference addressed itself to the following questions:

1. How can one call upon the existing interests and abilities of students whose prior orientation has been non-scientific so as to obtain their enthusiastic participation in scientific activity?

2. What teaching techniques and what materials can be employed to transmit genuine understanding of science to large classes of non-science majors?

3. What topics from physics, chemistry, or allied sciences lend themselves to treatment in depth by students without strong backgrounds in mathematics or science?

Answers to these questions were sought by calling on the combined experiences of the conferees, and in particular by focusing attention on the written materials, apparatus, and visual aids used by several participants who had recently taught elementary science courses for such students.

Several major themes emerged rather clearly from the discussion which should serve as useful guides for the future. For one, course planners should not be restricted by boundary conditions which require complete coverage of the traditional topics of elementary physics and chemistry courses. No single topic is so important that its inclusion should override consideration of student interest and suitable style of treatment. Most conferees agreed that topics selected should illustrate the basic unifying principles of physical science, and only as secondary criteria should consideration be given to the historical role of a concept or the relationship a subject may have to the various goals of nonscience students.

There was unanimous agreement that laboratory should play a major role in the course. Students should be encouraged to learn facts by observation, to formulate models which encompass the observed facts and to perform further experiments to test the models. While this way of learning the scientific method is desirable, it should not be the only teaching technique employed. Ingenuity must be invoked to discover a variety of new approaches - augmenting lecture demonstrations, class discussions, visual aids, and library assignments - which will reinforce one another and relieve the monotony of the purely verbal approach.

Another point which was made emphatically concerns the legendary objectivity of the scientist, the austerity of his laboratory, and the inevitability of his logical arguments. Not only does this image misrepresent the actual processes by which science progresses, but it is likely to repel students whose main interest lies in inter-personal relations. The students should be permitted to see how the personalities of scientists and the fashions of their times influence the growth of scientific knowledge; they should be faced with some of the unsolved problems about which humans are curious and with the limitations of science in solving crucial world problems.

The traditional attitude the science teacher attempts to convey to students in helping them to understand physical phenomena is strongly analytical. The student is faced with a problem, either theoretical or experimental, and encouraged to discover those aspects of the problem which are simple enough to be related to a broad generalization. It was urged strongly by Phil Morrison that many of the learning situations provided for nonscience majors should have a more synthetic flavor. Students should be provided with simple materials from which they are asked to construct or design something, thereby learning new principles or reinforcing some already known. (More complete views of Dr. Morrison on this and other subjects related to the teaching of science to nonscience majors are contained in the transcription of the talk he delivered at the conference.)

Finally, there was considerable discussion at Rosemont directed at the problem of how to teach a challenging laboratory centered course in the college or university framework to the large numbers of students that need and will demand a good course in physical science. While no sure solutions have been discovered as yet, it was agreed that great effort should be expended in exploring the feasibility of relying heavily on programmed learning, take home apparatus kits, closed circuit television, films and film loops, and a host of other modern techniques. It is certainly true that any new course development which is not adaptable to mass teaching will be of limited value in providing science education for non-science majors in the modern age.

Attention was also paid to mechanisms by which the general plan of attack outlined above may be implemented. Scientists from several universities have expressed interest in exploring the possibility of submitting a proposal to hold working sessions at their institutions. It is hoped that enough interested scientists have been convinced of the importance of the project to form a nucleus for a steering committee and a working group. Cooperation in having the initial materials tried at state colleges in New York and Pennsylvania seems assured.

New York-Pennsylvania Regional Conference on the Preparation of a Physical Science Course for Non-Science Majors

Rosemont, Pennsylvania

October 18-19, 1963

Participants

David G. Barry, Geology	Atmospheric Sciences Research Center, Albany, New York
Lewis G. Bassett, Chemistry	Rensselaer Polytechnic Institute
Peter G. Bergmann, Physics	Yeshiva University
Leo J. Brandenburger, Industrial Design Engineer	Philadelphia, Pennsylvania
Sidney M. Cantor, Chemistry Consultant	Ardmore, Pennsylvania
Ralph Caplan, Writer	New York
Walter Eppenstein, Physics	Rensselaer Polytechnic Institute
Harold M. Faigenbaum, Chemistry	Rensselaer Polytechnic Institute
Harold B. Gray, Chemistry	Columbia University
Cilbert P. Haight, Chemistry	Swarthmore College
George W. Hazzard, Physics	General Electric, Schenectady
Alan N. Holden, Chemical Physics	Bell Laboratories, Murray Hill
Harry F. Meiners, Physics	Rensselaer Polytechnic Institute
Walter C. Michels, Physics	Bryn Mawr College
Philip Morrison, Physics	Cornell University
V. Lawrence Parsegian, Engineering Physics	Rensselaer Polytechnic Institute
Charles C. Price, Chemistry	University of Pennsylvania
Albert J. Read, Physics	State University of New York at Oneonta
Frank Reynolds, Chemistry	West Chester State College
Russell K. Rickert, Physics	West Chester State College
Miss Phylis Singer, Teacher	Short Hills, New Jersey
Clifford R. Swartz, Physics	State University of New York College at Stony Brook
William U. Walton, Physics	Webster College, Webster Groves, Mc

Commission on College Physics Staff:
E. Leonard Jossem   Edward D. Lambe   Arnold A. Strassenburg

NEW YORK-PENNSYLVANIA CONFERENCE ON PHYSICAL SCIENCE COURSES

AGENDA

Friday, October 18, 1963

Afternoon Session

2:00	Welcome and Introductory Comments	- Walter C. Michels
2:30	Discussion	
3:30	Coffee	
4:00	"Where do we stand now?"	- Edward D. Lambe
5:00	Crystals--film by Alan Holden	
5:30	Discussion	
6:00	Dinner	

Evening Session

8:00	"Ways to make physical science meaningful to prospective elementary school teachers"	- Phylis Singer and William Walton
9:00	Discussion	

Saturday, October 19, 1963

Morning Session

9:00	"Desirable Characteristic for a Physical Science Course for Nonscience Majors"	- Phil Morrison
10:30	Coffee	
11:00	"How do we begin?"	- Charles Price
11:30	Discussion	
12:30	Lunch	

Afternoon Session

2:00	"Possibility of organizing working group at Rensselaer Polytechnic Institute"	- Lewis Bassett
2:30	Discussion	
3:00	Group A: Discussion of mechanisms for organization and direction of project. Group B: Discussion of appropriate course topics and methods of treatment.	

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APPENDIX A-3

The Boulder Conference

Jul 2-29,1964

Relevant pages of The Proceedings of the Boulder Conference on Physics for Nonscience Majors.

REPORT OF THE PHYSICAL SCIENCE COURSE GROUP

Boulder Conference on Physics for Nonscience Majors

Members: Malcolm Correll, chairman, Robbin Anderson, William Cook, David Gavenda, George Hazzard, Melba Phillips, Arnold Strassenburg, Edwin Uehling, James Werntz, Elizabeth Wood.

Visitors who made valuable contributions: Arnold Arons, H. R. Crane, Howard Pincus, Theodore Puck.

Summary of Preliminary Planning Session

Proposed Time Schedule:

Wednesday, July 22 - Broad outlines to be considered: blocks of material, thematic lines, laboratory, and others to be defined.

Thursday, July 23 through Saturday, July 25 - Collaboration with other groups with overlapping interests-- e.g., apparatus. Detailing of broad outlines.

Monday, July 27 and Tuesday, July 28 - Generation of longer range programs. Assistance to proposed writing groups at Rensselaer and The University of Texas.

General Aims:

(1) To define several ways in which physical science courses may be improved.

(2) To develop some sample materials.

(3) To formulate proposals for further work.

Summary of Group Accomplishments

The objective of the group was to outline a course which might be desirable as a formally terminal course in physical science for many students who may be prospective elementary school teachers, but which might also lead to (1) further courses in physics of the S-curriculum type or (2) a second year of natural science involving more biological or geological applications.

In addition to subject matter topics, the group considered other aspects of a course, such as pervading themes, films, collateral readings, demonstrations, laboratory, etc. Except for a few general conclusions and a few particular suggestions, some of which are listed herewith, most of the discussion centered around a particular outline. This outline was proposed by M. Phillips as a variation of a course outline presented at the conference by W. D. Knight, including more chemistry as suggested by R. C. Anderson. An expanded version of that outline is included herewith, both as a possible course very much as it stands in skeletal form, and to illustrate problems and difficulties which arise in designing an integrated interdisciplinary course.

A decision was made that the structure of the course be decided on subject matter grounds, with several themes (e.g., symmetry, conservation, etc.) to be kept consciously in mind, emphasized as appropriate, but not dominating the organization of the material.

On laboratory work, some ideas were collected on more or less formal exercises, but the development of sufficiently programmed take-home kits should be encouraged to benefit the less imaginative and original students. Perhaps films of the type produced by Ray and Charles Eames and shown by them at the conference might be useful in this and other connections. In any event, the course should be kept very closely related to the students, with active student participation in observations and experiments.

Some work was also done on the less complete outline proposed by E. A. Wood. It is hoped that it may be further developed at future conferences. There was also discussion of the desirability of a more flexible course, with a core and optional units, but this project seemed less urgent on practical grounds.

Copies of the outlines considered appear on the following pages.

A Course Outline Suggested by Melba Phillips

1. Start with perception, possibly using a film.

2. Geometrical optics, small angle approximation emphasized. Fermat's Principle.

3. Waves and light. PSSC materials useful. Ripple Tank. Extension to gratings in one and two dimensions, as in beginning of Holden-Germer film.

4. Crystals and waves, as in Holden's book or W. D. Knight's Expanded Course Outline. Look at cleavage. Unit cells, as done by Hauy. Reasonableness of the Bragg Law.

5. Atoms. Descriptive chemistry, up through empirical periodic table. Atoms are Daltonian, without structure. Spectra, as characteristic of analysis without theory, as done historically. (3 to 4 weeks on this section.)

6. Gases. Motion of atoms evidenced by diffusion, Brownian Motion, even change of state. Pressure, leading to ideas of force. (See W. D. Knight's Expanded Course Outline.)

7. Kinematics and dynamics of particle motion, through momentum and mechanical energy. (See PSSC, for example.) Simple harmonic motion. Gravitational forces. Solar system and satellites.

8. Kinetic Theory. Ideal and (qualitatively) non-ideal gases. Equipartition, including simple model of solids. Specific heats.

9. Heat; randomness. First and second laws of thermodynamics. Conservation of energy as a generality. References: PSSC advanced topics; Cowling. Entropy, at least qualitatively.

10. Electrostatics and magnetostatics, with magnets and Ampere's hypothesis. (The Biot-Savart Law, but no time for the law of induction or displacement currents.)

11. Evidence for atomic structure and for the quantum: electrochemistry, gas discharge, e/m experiments, spectra, photoelectric effect, specific heat (failure of Dulong-Petit Law), Millikan oil drop experiment, etc.

12. Simple Bohr theory. Periodic table, with electrons and Pauli Principle. (Four quantum numbers. Angular momentum can be obtained from the law of equal areas. Quantize; invoke spin as empirical.)

13. De Broglie hypothesis. Uncertainty principle. (Fuzz out the orbits of the Bohr-Sommerfeld picture. Eames type film useful?)

[The next step presents a genuine difficulty. We have all been very cavalier in applications to obtain chemical bonding and have been unpleasantly reminded of this by seeing some CHEM Study films at this conference. It will take much work, but we must get more cleanly to the next topic.]

14. Chemical bonding -- ionic, covalent, etc.

15. Carbon chemistry (rather geometrically, invoking symmetry as done by Pasteur-le Bel, Van't Hoff), leading to macromolecules through models, and to some aspects of biochemical elements.

A Course Outline Suggested by Elizabeth Wood

Guiding principles:

1. To teach that science is the continuing effort of the human mind to comprehend relationships.
2. To encourage the instructor to teach some things he especially wants to teach.
3. To proceed from the familiar to the unfamiliar by way of the need to know.

Useful techniques:

1. Shelve unfinished business and return to it later in the course.
2. Whenever possible, relate topics discussed to the students' first-hand experiences.

Topics and some suggestions for their treatment	First-hand Experiences
"Here is an object." Concept of properties of a substance. Measurement.	Copper sulfate and alum in solution.
Discover refraction and dispersion of light. "Maybe we'd better find out about light." Metals vs. nonmetals (on shelf) Polarization (symmetry). Color (wavelength range) -- diffraction. X-rays - diffraction. Gamma rays (on shelf)	Experiments with light.
Grating spacing (new kind of length meas.). Crystal Structure.	Collodian replica to play with?
Regularity --- randomness. Melting and freezing. Heat. Kinetic Theory. Conductivity - metals vs. nonmetals - Radiation (longer λ waves) (on shelf)	Crystals from melt of rocks (made up of crystals).
"How is the [copper sulfate and alum] coming?" Systematic chemistry.	Chemical experiments.
Adding heat changes liquid to gas! Gases. Avagadro's Number. Pressure. Sound. Force. Kinematics.	Experiments with sound.
Dynamics, with special attention to rockets and satellites. Simple harmonic motion. Conservation of Energy.	Let them raise children's questions.
Solar system. Gravitation.	Astronomical observations.

"Are there other forces?"
Electrostatic forces.
   Ionic and covalent bonding.
   Metals (the delayed aha!)
   More about electrons: the electronic charge.
      The Faraday - Avagadro's Number - wavelength of X-rays - cell size interrelationship.
	Coffee-can electrometer.
	Electrostatic experiments.

Fields, currents, magnetism. Electromagnetic radiation. Electron diffraction (Davisson-Germer anecdote). DeBroglie relation. Photoelectric effect. Spectra. Energy levels. Atomic structure. The nucleus. Mass defect. Nuclear energy.	Experiments with needle, wire, dry cell. Hallwach's experiment.

A Course Outline Suggested by James Werntz

A Multi-channel Approach

I. Symmetry

An introduction to scientific thinking through the aesthetics of space and time.

1. Geometrical optics.
2. Crystals.
3. Kinematics: reference frames; special relativity; principle of equivalence.
4. Chemical reactions.

II. History

An introduction to scientific thinking through an understanding of where we have been and how we have proceeded (i.e.: science as a cumulative activity).

1. The Newtonian Synthesis: solar system mechanics; determinism.
2. Phenomenological chemistry: the periodic table.
3. Phenomenological nuclear physics: the nuclide chart.
4. Technology and science.
5. The gas laws and Kinetic Theory.

III. Continuity

To illustrate the power and beauty of the field concept; action at a distance through continuous media.

1. Hydrostatics and hydrodynamics.
2. The inverse square law; potential theory.
3. Magnetostatics.
4. Electrodynamics.
5. Chemical thermodynamics.

IV. Quantization

To illustrate the development of new abstractions built on old.

1. Music: resonance, normal modes.
2. Physical optics: what interferes and what do we see?
3. Particle waves: what interferes and what do we see?
4. Atomic structure -- especially the blurred (i.e.,normal mode) Bohr model.
5. Molecular structure and macromolecules.

V. Uncertainty

1. Measurement: statistical variation from ignorance?
2. Kinetic Theory: "certainty" from uncertainty.
3. The statistical view of nature: statistical variation fundamental?

APPENDIX B-1

Original Proposal to the National

Science Foundation

November 1964

PROJECT PROPOSAL SUMMARY SHEET

This proposal is submitted to the Course Content Improvement Section, Division of Scientific Personnel and Education, National Science Foundation.

SUBMITTED BY:	Rensselaer Polytechnic Institute Troy, New York
TITLE:	DEVELOPMENT OF A COURSE IN PHYSICAL SCIENCE FOR NONSCIENCE MAJORS
PROJECT DIRECTOR:	Dr. Lewis G. Bassett Professor of Chemistry, R.P.I. Ashley 2-3000, Ext. 396 - Area Code 518
STARTING DATE:	April 1965
DURATION:	18 months
AMOUNT OF SUPPORT REQUESTED	$249,435

ABSTRACT: A program is proposed to develop a course in physical science to be given in liberal arts colleges and teacher training institutions to nonscience majors, particularly those who intend to become elementary school teachers. The program is to extend over a period of eighteen months including two summer workshop sessions and one and one-quarter academic years. A group of from fifteen to twenty scientists and educators will work in the summer sessions developing materials for use on a trial basis in a number of colleges in the academic years following the summer sessions. The materials developed will include a text for students, a resource book for teachers, a set of experiments, and a survey of available teaching aids. During the academic year the Director will be assisted in evaluation and further development by the trial teachers in the academic institutions in which trials are being held, and by the advice and counsel of an Advisory Board of eight members which includes two Associate Directors and representative scientists and educators from educational institutions, industry and other agencies interested in the problem. It is the aim of the program to have materials for use in academic institutions available for publication at the end of the second summer session.

Lewis G. Bassett
Project Director

R.H. Hartigan, Director
Research Division

PROPOSAL
FOR THE DEVELOPMENT OF A COURSE IN PHYSICAL SCIENCE FOR NONSCIENCE MAJORS

I The Problem

We propose to develop a new college course in physical science having, as its primary goal, the sensible scientific education of college students who have no current intention of taking up scientific careers. A second goal, which is really included in the first but deserves special mention, is the training of elementary school teachers for the delicate task of drawing out the spirit of inquiry in their future pupils without destroying it.

One of the precious gifts of childhood is a driving curiosity about the world. The child asks without prejudice, persists without embarassment, and experiments without fear. The search for truth is pleasant to him, and so are the rewards of discovery. He is in these respects an incipient scientist. Since the instinct within him is already strong, his teacher's problem is only to keep it alive in healthy growth toward maturity. And the college's problem is to train people to guide the child with knowledge and compassion.

The great obstacle in the path toward these goals is a barrier of language. Among most scientists, including those who teach in colleges, the professional jargon is a mother tongue. Having learned it in our youth, and having used it exclusively in our professional lives, we find it difficult to translate science into languages which can impart sound scientific knowledge to people whose interests and aptitudes are far from our own. Thus learning science from our textbooks is, as Professor Morrison remarks, for most people like learning English from books on contract law. The problem to which we propose a solution is the breaking of this pattern in a course that can stand alone, outside the intensive professional curricula. We are looking at large numbers of students, engaged mainly in the study of liberal arts, who seek a brief but effective experience in natural

science. Those whom our most careful efforts must reach are the future teachers in the elementary schools, since it is only they who can give a new mother tongue to the next generation.

Part II of this document is a review of the brief history of meetings leading to our proposal. Part III is a description in detail of the course that we plan to evolve, of the organization which we shall create for this purpose, and of cost estimates. We attach, as appendices, further documentation bearing on the project.

II Recent Background

At Chicago in September 1963, the Advisory Council on College Chemistry and the Commission on College Physics called a conference of about forty people -- chemists, physicists, and representatives of state education departments -- to study the problem that now concerns us. The conferees recommended that efforts be made by several separate groups of scientists to create one-year introductory college courses combining the fundamental concepts of chemistry and physics. They suggested further that close attention be given to the scientific education of nonscience majors, including in particular the group of prospective elementary school teachers. A review in detail of the conference is attached as Appendix I to this proposal.

Out of the Chicago conference grew a desire among scientists and educators from New York and Pennsylvania to implement these recommendations. The group explored their resources during a regional conference at Rosemont in October 1963. They also attempted at the time to define the spectrum of academic and temperamental characteristics of the students to be reached, and the features of a course which might excite and maintain their involvement. A report of this conference is attached as Appendix II.

At a conference on physics courses for nonscience majors, held at Boulder in July 1964, a group undertook to create outlines for physical science courses. A review of their activities is included in Appendix III.

An outcome of the Rosemont conference was the identification of Rensselaer Polytechnic Institute as a place where leadership and facilities can be found for an energetic pursuit of course development. In September 1964, twenty scientists, some of whom are now committed to service in the program, met at Rensselaer to form a plan of action. The deliberations of this group constitute most of the work leading to this proposal.

III Proposed Program

A. The Course

1. General Description

The course is to be a one-year course in Physical Science for the nonscience major who is not planning to take additional physical science courses. It will introduce the student to physical phenomena through experimental activity. While it will be designed to meet the needs of the prospective elementary school teacher, it is anticipated that it will be found useful for a broad group of nonscience majors in the liberal arts colleges.

2. Basis of the Approach

To develop a course to achieve the goals described in section I of the proposal is a formidable task. There are certain restricting or boundary conditions which are definitive in determining the nature of the course. First is the meager background of the prospective students in science and especially in mathematics. Second is the time (one-year) which can be allotted to a course in physical science Third is the rather general lack of interest in and even antipathy toward science frequently expressed by nonscience majors particularly those who plan to be elementary school teachers.

With these limiting conditions in mind there are a few general principles which have served as guides in the development of the Course Plan which is given in the next section of the proposal.

(a) The purpose of the course is to develop in the student a sympathetic attitude toward science and an understanding of the nature of physical science, of its methods and techniques, and

of its importance in the society of today and future. It is not the purpose to provide the future elementary school teacher with an organized course in third-grade science which he can later transmit to third-grade pupils. We envisage a science course, not a methods course.

Far from accepting a superficial view of science, the student must experience a deep involvement with the motivations, techniques, and intuitions underlying the accomplishments of physics and chemistry. He must be given a chance to feel enjoyment in experiment and excitement in discovery.

(b) Time for thoughtful observation, organization of material, and absorption of new ideas can only be provided through drastic restriction of subject matter.

(c) Although experiment and observation are fundamental to the course, we cannot assume that conventional laboratory space and facilities will be available at every college.

(d) The treatment of every topic must take into account the fact that the intellectual habits and natural temperaments of many students are verbal rather than mathematical. Long chains of logical argument are foreign to them, as are extended technical discussions whose ends are not clearly in sight. The prior experience that these people have had with tools and apparatus is likely to be slight.

(e) Textual material for the course is to be assembled, as far as possible, from existing sources or parts thereof, connected into a confluent whole by as much new writing as is necessary. Supplementary topics will appear as separate optional chapters of the text.

(f) Throughout the course, certain "threads" or themes of importance, which are characteristic of science, should be noted and emphasized again and again. These threads are:

(1) An appreciation in science of the beauty of order and symmetry, of the aesthetic choice of the most simple models and theories, and of the creative as well as the analytic nature of scientific work.

(2) The principles of conservation of certain physical quantities which are implicit in many deductive arguments.

(3) The aspects of behavior which are associated with discontinuity of functions and quantization of properties in many areas of science.

(4) The recognition of mathematics not only as a time and space-saving system of notation, but more importantly as a way of refining, simplifying and generalizing concepts.

3. Course Plan

The plan for the course has resulted from agreement on these general guiding principles in addition to further specific ones which have permeated the thinking of the group in various forms, but may fairly be summarized as follows.

(a) The course should give the student a sense of participation in the effort to understand the physical world, a sense of the nonauthoritative nature of science.

(b) The instructor should be encouraged to teach some things he especially wants to teach so that his enthusiasm for the subject may be caught by the students.

(c) Where possible one should proceed from the familiar to the unfamiliar by way of the need to know.

In order to achieve the desired freedom of choice (b, above) we want to create many " optional packages" of material from which the instructor may choose those that appeal to him. However, we feel that most instructors would feel insecure about a course which consisted entirely of optional packages and, further, it is useful to have a body of basic knowledge which may be assumed for these packages. In other words, the course must have a consecutive, self-dependent body of material which, for want of a better word, we shall call the " core". This material should be central to the interlocking areas of physics and chemistry. We have chosen as a focus of the core material the structure of matter. A different focus would have resulted in a somewhat different core.

The need for repeated reinforcement of an idea, especially for the group we have in mind, will result in the conscious use of two techniques: first, which we call the "Here it is again" technique, the specific notice of previously encountered phenomena or principles when they arise in a new context and second, the use whenever possible of every-day experiences for illustration so that in the years following the course the reinforcement will continue and physical science will form a comfortable, familiar part of the student's life.

Because of this rediscovering, interlocking nature of the course as we see it, we have found it difficult to represent our concept of it in conventional outline form. The following unconventional form will indicate the direction of our thinking.

Optional packages are indicated in parentheses. In a number of cases, the "optional" refers rather to the extent of the treatment. Such subjects as magnetism, for example will certainly be discussed briefly with the core material. The optional package category refers to deeper treatment. A few samples of experimental material are indicated in the right-hand column.

COURSE PLAN	MATERIALS FOR EACH STUDENT FOR FIRST-HAND EXPERIENCE
First class session. Start of an experiment of long duration.	Powdered substances in jars for solution and recrystallization. See "Take-home experiments" below. Also NaCl
"Here is an object. How do we find out about it?	Section of glass rod
Measurement. Scale. Errors in measurement. Notice refraction of light. Notice dispersion "Maybe we'd better find out more about light". Need to know.	Experiments with light, e.g., spoon in glass of water. Many good experiments here.

COURSE PLAN	MATERIALS FOR EACH STUDENT FOR FIRST-HAND EXPERIENCE
Light. Color. Interference, Diffraction. (Transverse oscillation). Grating spacing: a new kind of length measurement.	Soap bubbles. Collodion grating replica?
(Polarized light. Polarization by reflection. Note difference between metals and nonmetals in this and store this knowledge for later use.	Prism made with tilted mirror in pan of water giving a wedge of water
(Geometrical optics)	(Mirrors and lenses.)
(Periodic motion) (Kinetic and Potential energy)	(Pendulum experiments.)
(Sound. Longitudinal oscillation). (Frequencies. Pitch. Beat note.)	(Velocity of sound) (Pitch)
Wavelength range of light. Electromagnetic spectrum.	
" How are the substances in jars coming? Regularity. Significance?	Crystals grown in jars. Crystals from melt, salol. See " Chair-arm Experiment" below
X-ray diffraction: see " typical treatment of one topic", below	
(Crystal structure, more extensively)	(Experiments relating properties to structure)
(Symmetry)	Minerals, rocks.
Regularity and randomness. Melting and freezing. Melting points, boiling points.	Melting and boiling experiments.
Concept of kinetic theory of heat. Kinetic energy. " Here it is again". (Heat transfer mechanisms Metals vs. nonmetals. " Here it is again")	Simple heat experiments.
Forces between particles. More about force because of need to know. Solids, liquids and gases. (Behavior of gases) (Avogadro's number) Electrostatic forces	

COURSE PLAN	MATERIALS FOR EACH STUDENT FOR FIRST - HAND EXPERIENCE
Static Electricity (because of need to know) The Electron. Quantization of charge and light Photoelectric effect	Coffee-can electrometer Hallwachs experiment (UV radiation discharges a negatively charged electrometer, but not a positively charged one) (Longer wavelength radiation discharges neither.)
Electricity. Electrons in motion. Conductivity: metals vs. nonmetals " Here it is again," Structure (Further discussion of bonding forces) (Electromagnetism)	
Electrolysis of water Combining proportions Chemical evidence for atom. Dalton. Chemical reactions Ionization. Shared electrons (Discussion of chemical bond types)	Simple chemical experiments, at home. Familiar examples. Oxidation of iron, significance of need to have water present.
Periodicity of the properties of the elements. Periodic table. Structure of the atom. (Structure of the atom, in greater depth).	
Significance of spectra (Quantization of energy. More about energy because of the need to know) (Use of spectra in astronomy) (Distribution of elements)	Spectra with replica gratings. Sodium flame, neon lights, etc. Electromagnetic radiation " Here it is again"
Nature of chemical analysis. Meaning of "organic" and " inorganic" substances. (Biological chemistry. Macromolecules.)	Experiments with behavior of plastics Relation between Structure and properties. " Here it is again"

At this point we are concerned about the omission of the solar system and satellite kinematics as well as kinematics in general and about the omission of the nucleus. We hope to find the right places for optional packages on these subjects.

4. Typical Treatment of One Topic

The instructor and the class are considering the substance, sodium chloride. The instructor displays a large single crystal and cleaves it several times. The students are already familiar with this solid, having already grown crystals of their own. They are reminded at this point that a crystal maintains its shape as it grows, suggesting to us that it builds itself with layers of material. Also, since we cannot see discontinuities in growth, the layers must be thin. We now seek ways of verifying this idea. If the instructor has discussed waves and diffraction previously, he reminds his students of details of the diffraction phenomena. Otherwise he must take time to introduce the necessary parts of that discussion, perhaps with demonstrations of grating and wire-mesh diffraction in order to emphasize the notion of periodicity in more than one dimension.

Following up this idea, the class investigates optical diffraction by screens of several mesh sizes and learns how to determine the periodic structure of the screen from the properties of the diffraction pattern. Then they study X-ray patterns from sodium chloride and draw conclusions about the grating spacings and symmetries of the crystal. Finally, they study the chemical and physical properties of NaCl, learning how these are related.

5. Experimental Formats

If the laboratory is successful, it will bring out some of the art of asking sensible questions, collecting data, describing observations, and interpreting results. The student will have the chance to design ways of supporting his conclusions, working, in some cases, with equipment he can build himself. We will encourage him in every possible way toward a first-hand acquaintance with the crucial phenomena of physics and chemistry and an appreciation of the critical role that experiment plays in science. The participation in the intellectual, and even tactile, pleasure of experimentation is a rewarding experience.

It will probably not be necessary to develop a large number of new experiments for this course. Some are available in satisfactory form; others can be modified. The thing to invent is a variety of classroom and out-of-class formats for the laboratory. In the following table, we identify six such formats, giving in each case an example of an experiment.

(a) In-lab. Experiments in this category, for reasons of economy, complication, or hazard, can only be performed in the usual laboratory setting. Example: Electrolysis of molten NaCl.

(b) At-home. Experiments involving little or no special apparatus, using materials easily available in kit form. Example: Multiple crystal growth. $KCr(SO_4)_2 \cdot 12H_2O$ in one case, and $CuSO_4 \cdot 5H_2O$ + $KAl(SO_4)_2 \cdot 12H_2O$ in another. (See below).

(c) Chair-arm. Experiments to be done at the desk in class, using simple apparatus. Example: Growth of salol. (See below).

(d) Subgroup. Experiments done by a small group of students for study and analysis by all. Example: Optical, electron, and microwave diffraction.

(e) Instructor. Experiments set up and operated by the instructor for study and analysis by students. Example: Diffraction of light by window screen.

(f) No-lab lab. "Experiments" based only on tabulated data. Example: Physical properties of crystals.

It is realized that many institutions, which might wish to introduce the proposed course in the curriculum, would not be able to make conventional laboratory facilities available, particularly with large classes. The use of the formats in categories (b) through (f) is, therefore, a necessity. To further illustrate the type of work that can be done with inexpensive kits and equipment, a more complete description of typical experiments in categories (b) and (c) are given below.

At-home Experiments

In the following three experiments, the student receives a small screw-capped jar containing a mixture of finely powdered substances,

takes it home, adds water, shakes it until the powder dissolves, and then uncaps the jar and sets it on a shelf to await crystallization.

(1) A blue and a white powder go into solution forming a single homogeneous fluid. Two very different crystals then come out of solutions, a bright blue triclinic crystal and colorless cubic crystal. Copper sulfate and alum. $CuSO_4 \cdot 5H_2O$ and $KAl(SO_4)_2 \cdot 12H_2O$

(2) A purple and a white powder go into solution forming a single homogeneous fluid. A single type of crystal, intermediate in color between the two then comes out of solution. Potassium alum and chrome alum.
$KAl(SO_4)_2 \cdot 12H_2O + KCr(SO_4)_2 \cdot 12H_2O \rightarrow 2K(Al,Cr)(SO_4)_2 \cdot 12H_2O$

(3) A white and a green powder go into solution and a brownish red substance comes out. Potassium sulfate and chromic sulfate. $K_2SO_4 + Cr_2(SO_4)_3 \cdot 5H_2O + 19H_2O \rightarrow 2KCr(SO_4)_2 \cdot 12H_2O$

Comparison of the results of these three experiments leads to a discussion of solution and recrystallization, purification by crystallization, solid solution and chemical reaction.

Chair-arm Experiment

Salol, phenyl salicylate, available in most drug stores, melts at 42°C, and can therefore easily be melted on a microscope slide in a match flame. On crystallizing it forms orthorhombic crystals whose faces may be as large as 3/8 in. long. The melt supercools and usually has to be seeded to initiate crystallization. The crystals of course maintain their "diamond" shape as they grow, a sight which carries convincing evidence of the orderly accretion of atoms. The experiment also provides first-hand experience with supercooling. It has been successfully performed by every student in a class of 34 and could be performed in a class of several hundred, if necessary, on the arms of the lecture-room chairs.

6. Output Materials

The development of the course will include the production of materials for the use of teachers and students. These materials will be developed during the working session of the summer of 1965 in sufficient quantity for use on a trial basis by no less than five teachers in liberal arts or teacher training colles who have participated in the development during the summer. After an academic year (1965-66) of trial, these materials will be revised at a working session in the summer of 1966. Their publication will be an activity of the following academic year (1966-67). These materials are listed and discussed briefly below.

(a) A text for students

The text will consist of excerpts from existing books, paperback or hard-cover, connected into a confluent whole by as much newly created text as is necessary. Although one has the general impression that there are many good science paperbacks these days, inspection of several with this particular course in mind suggests that much newly created text will be necessary. The optional material will occur in an appropriate position in the text, but each unit of it will be a separate chapter so that it may be omitted if desired. The books from which the excerpts were taken should be available for student reference as should other selected references.

(b) Resource book for teachers

The development of a resource book for teachers is a diffip cult but essential task. It will be the document which unifies the various course experiences. It will provide the roadmap which enables the teacher to plot an intelligent course through a rich array of materials. In its final form, the book will also contain material found in the conventional teachers guide, e.g., problems with answers, sample quizzes and examinations, suggested course schedules, etc.

(c) Experimental exercises

A set of experimental exercises, some taking their inspiration from existing literature, some developed during the summer, will provide a storehouse of novel ideas for experiments conducted in the various formats previously described. The book must be written in such a manner that it will meet the needs of both the student and the teacher. For example, in addition to directions for conducting individual experiments, there must be general instructions for the student for making observations, recording data and reporting results and conclusions. Also the range of experiments presented must be sufficient to permit the teacher some flexibility in choosing material suitable for his particular needs.

(d) Other teaching aids

A critical review will be made of the numerous instructional aids which are now available to the teacher. Lists of recommended films and film strips, programmed instruction manuals, demonstrations and materials for overhead projection, etc. will be compiled. These lists will be compiled by evaluating existing sources, and will not involve a major creative effort in the summer session. The group charged with these tasks should also determine, however, how these aids fit into the remaining structure of the course, and make recommendations on what additional aids may be needed to amplify the treatment of certain topics.

B. Organization of the Project

1. Schedule of Activities

A chronological schedule of activities, following the initiation of the project, is outlined here and further discussed below.

(a) A planning session of an Advisory Board (spring 1965).

(b) A working session in the summer of 1965.

(c) Activities during the academic year 1965-66.

(d) A working session in the summer of 1966.

(e) Summer Teacher Training Institute- 1966 (separately funded).

(f) Meeting of Advisory Board (fall 1966).

2. The Advisory Board

The experience of other educational research programs of this type has shown the advisability of an Advisory Board made up of scientists, teachers and educators. The Board will hold six to eight meetings at regular intervals during the duration of the project and advise the director on planning initial activities, evaluating progress, and suggesting future activities.

A Board of eight members is proposed. The following persons have agreed to serve in the positions indicated.

(1) Director - Lewis G. Bassett, Professor of Chemistry, Rensselaer Polytechnic Institute.

Officer (1943-46), Manhattan District, Corps of Engineers, AUS, (Research Engineer).

Scientific Editor (1958), United Nations, in the publication of the Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy.

Leader (1960-63), R.P.I. pilot program for revision of general chemistry course.

Editor and co-author (1962-64), ''Principles of Chemistry'' now in publication with Prentice-Hall, Inc.

(2) Associate Director - Elizabeth A. Wood, Research Physicist, Bell Telephone Laboratories, Murray Hill, N.J.

President (1957), American Crystallographic Association.

Adjunct Professor of Physics (1963-), Fairleigh Dickinson University (Madison campus).

Author, ''Crystal Orientation Manual'' (Columbia University Press, 1963), ''Crystals and Light - An Introduction to Optical Crystallography'' (D. VanNostrand Company, 1964), and a color sound film ''Crystals- An Introduction''.

(3) Associate Director - Robert I. Sells, Chairman, Physics Department, State University of New York College at Geneseo.

Director (1959-63), NSF Summer PSSC Institutes.

Chairman (1962-), High School Awards Committee, AAPT.

Member (1964-), College Proficiency Examination Committee, University of the State of New York.

American Institute of Physics Regional Counselor for New York State.

Co-author, ''Elementary Modern Physics'', Allyn and Bacon, 1960; ''Elementary Classical Physics'' (2 volumes), Allyn and Bacon, 1965

(4) A Representative of the Commission on College Physics-
Robert Resnick, Professor of Physics, Rensselaer.

Member (1960-), on Executive Board (1960-64), CCP.

Director (1958-) of a number of NSF-sponsored summer programs at Rensselaer for the development of apparatus and demonstration experiments in physics.

Director (1958-60), R.P.I. pilot program for revision of general physics courses.

Co-author, ''Physics for Students of Science and Engineering'', John Wiley and Sons, 1960 and 1962.

On leave of absence at Harvard, academic year 1964-65.

(5) A Representative of the Advisory Council on College Chemistry-
C. C. Price, Chairman, Department of Chemistry, University of Pennsylvania

Chairman, ACCC.

President (1965), American Chemical Society.

(6) A Representative of Industry-
Alan Holden, Research Chemist, Bell Telephone Laboratories, Murray Hill, N. J.

Member, The S curriculum project.

Member, Advisory Board of the Texas project for the development of a physical science course for nonscience majors.

Author, ''Crystals and Crystal Growing'', Doubleday Anchor Book; ''Conductors and Semiconductors'', Bell Telephone Laboratories, 1964; and two PSSC films.

(7) A Representative of the New York State Department of Education -
Frank R. Kille, Associate Commissioner for Higher Education.

Dr. Kille is a zoologist. He has served on the faculty at Swarthmore; he was for eleven years Dean of Carleton College, Minnesota; he has occupied his present position since 1958.

(8) A Representative of the American Association for the Advancement of Science -
Arthur H. Livermore, Deputy Director of Education for AAAS.

Dr. Livermore is on leave from his position as Professor of Chemistry at Reed College. He is also a member of the Advisory Board for the Texas project.

3. <u>Working Group - Summer 1965</u>

In the 8-week summer session of 1965, the working group will have the responsibility of emphasizing and organizing the ideas which will make possible the development of the course. During this period, also, written material for the course will be developed in sufficient detail and adequate form so that it may be used on a trial basis in a number of teacher training institutions during the following academic year (1965-66). Among the participants (see below) in the summer session are teachers in such institutions so that a trial seems assured in a number of institutions in the Northeast and the West.

The working group will be divided into four subgroups, each having the responsibility of developing the material for one of the types of activities listed in section A-6. Each subgroup will have a leader. Professor Sells of Geneseo will lead the group developing a text for students; Professor Bunce of Rensselaer, the group developing the resource book for teachers; Dr. Wood of Bell Laboratories, the group developing experimental exercises; and Professor Eppenstein of Rensselaer, the group evaluating and developing other teaching aids. All groups will meet together two or three times a week for correlation and integration of ideas and efforts.

Although a precise listing of the personnel of the summer session is not possible until a firm commitment can be made, a considerable number of persons have expressed an interest in participating if financial and living arrangements can be arranged. Among these are four members of the Advisory Board: Professor Bassett of Rensselaer, Professor Resnick of Rensselaer, Dr. Wood of Bell Laboratories and Professor Sells of Geneseo. In addition to these, the following persons are listed.

S. C. Bunce - Department of Chemistry, Rensselaer 1/2

Prof. Bunce has been for several years the Director of the NSF-sponsored Summer Institute in the Natural Sciences for Secondary School Teachers and has taught the first chemistry course in that program. He has been active in the revision of the general chemistry course at Rensselaer and is a co-author of the text ''Principles of Chemistry'' now in publication by Prentice-Hall, Inc.

Earl Carlyon - Department of Physics, SUNY Geneseo

Mr. Carlyon has been a high school science teacher for a number of years. During that time he has acquired a Master of Science for Teachers (M.S.T.) degree from Cornell and has taken summer preparation courses for teaching PSSC physics, CBA chemistry and CHEM study chemistry, all three of which he has taught in high school. During the present year he is at Geneseo teaching elementary physics (PSSC) and physical science.

H. G. Cassidy - Department of Chemistry, Yale University

Prof. Cassidy, whose technical field is adsorption and chromatography, is also active in the interpretation of science to the layman. He is the author of ''Science and the Arts'', 1962. He teaches a course at Yale in science for students in the humanities.

H. R. Crane - Department of Physics, University of Michigan 1/8

Prof. Crane is an experienced teacher of physics for nonscience majors. He is imaginative and creative in designing experiments and problems for such a group.

Philip Dilavore - Department of Physics, University of Michigan

Mr. Dilavore is a high school physics teacher who is just getting his Ph.D. in physics at Michigan. During the 1965-66 academic year he will be working in education and physics at the University of Maryland.

W. E. Eppenstein - Department of Physics, Rensselaer 1/2

Prof. Eppenstein is a leader in the development of visual aids for science education. He has been a member since 1960 of the Visual Aids Committee of AAPT. He has been a co-director with Prof. Resnick in NSF-sponsored summer programs for the development of apparatus and demonstrations for college physics. He has also been an assistant director with Prof. Bunce in the Summer Program in the Natural Sciences for Secondary School Teachers. He is the author of ''Physics Series Overhead Transparencies'', Text-Film Division, McGraw-Hill (1964), and co-author of ''Analytical Laboratory Physics'', J. W. Edwards, 1956 and 1959.

T. D. Goldfarb - Department of Chemistry, SUNY, Stony Brook

Prof. Goldfarb has been working with Prof. Clifford Swartz of the Physics Department at Stony Brook in planning the development of a content course in science directed at Elementary School Teachers. He attended the Rensselaer conference in September.

D. F. Holcomb - Department of Physics, Cornell 1/8

In cooperation with Prof. Philip Morrison, Prof. Holcomb has designed the physical science course for nonscience majors that he teaches at Cornell. He has made valuable contributions at the Boulder and Rensselaer conferences.

H. B. Hollinger - Department of Chemistry, Rensselaer 3/4

Prof. Hollinger has been active in the revision of the general chemistry course at Rensselaer and is a co-author, with Prof. Bassett and Prof. Bunce, of the text "Principles of Chemistry" now in publication by Prentice-Hall, Inc. He is also a member and active participant in the program of the New England Associations of Chemistry Teachers.

J. L. Katz - Department of Physics, Rensselaer 1/2

Prof. Katz is a respected research crystallographer. He has also been active in developing and teaching the general physics courses at Rensselaer. In addition he has been effective in presenting lectures in science to large groups of high school students.

N. J. Kutzman - Department of Physics, Montana State College, Bozeman, Mon.

Prof. Kutzman is Director of the Visiting Scientists Program for High Schools in the State of Montana. He has had considerable experience at Montana in teaching physics to nonscience majors. He feels that the proposed combined course in physical science is more appropriate for his group, many of whom become elementary school teachers. He wants to work on the production of this course and to try it out in Montana.

H. M. Landis - Department of Physics, Wheaton College, Mass.

Prof. Landis has taught physics both in school and a women's college. He is interested in the development of this course for use in the department which he heads at Wheaton.

Kent Lawson - Department of Physics, Bennington College

Prof. Lawson is a teacher of physics in a college which puts strong emphasis on the arts. He is experienced in winning the interest of disinterested students.

H. F. Meiners - Department of Physics, Rensselaer 1/2

Prof. Meiners has been closely associated with Prof. Resnick and Prof. Eppenstein in the NSF educational programs mentioned above. In addition he was the Director of the NSF-sponsored Satellite Film Projects (1957-1962). He is Editor and Co-Director of Reference Source on Demonstration Experiments in Physics, and co-author of ''Analytical Laboratory Physics'', J. W. Edwards, 1956 and 1959.

A. J. Read - Department of Physics, SUNY Oneonta

Prof. Read attended the Rosemont conference. He wishes to have a part in the development of this course for possible trial with his students at Oneonta.

R. K. Rickert - Department of Physics, Westchester State College, Pa.

Prof. Rickert also attended the Rosemont conference. His interests and plans are similar to those of Prof. Read above.

James Werntz - Department of Physics, University of Minnesota 1/8

Prof. Werntz is the father of four children. Perhaps this explains why he has been active in the organization of the Minnemast project to develop science materials for elementary school children. This project finds that teacher training is necessary for the effective use of these materials. He wishes to participate in the Rensselaer program and assist in filling this need.

Ja/ Young - Department of Chemistry, King's College, Pa.

Prof. Young is a member of the ACCC. He has long played an active part in the activities of the Division of Chemical Education of the American Chemical Society. He attended the Rensselaer conference in September. He is interested in playing a part in the development of this course for possible trial with his students at King's College.

The fractions in the right-hand column indicate a minimum estimate of the fraction of time which may be devoted to the 1965 summer session by those who cannot be present full time. Further recruitment of personnel is necessary and is in progress.

4. Academic Year 1965-66

Three types of activity will continue during the academic year 1965-66 in the interim period between the two summer sessions.

(1) Trial of material in five teaching institutions by five teachers who participated in the summer session.

(2) Four sessions (two each semester) of the Advisory Board. The five trial teachers will meet with the Board during the sessions. These teachers will continue on this project during the academic year on a consultant basis.

(3) It is anticipated that the development started during the first summer can profitably be continued through the following academic year by eight to twelve people working at Rensselaer or at their own institutions in an amount equivalent to three full-time workers.

5. Working Group - Summer 1966

A smaller group (14), made up largely of participants in the summer session of 1965, will work for a similar average period of eight weeks during the summer of 1966. The task here will be to review the results of the trials of the preceding academic year, to revise and amplify the course material where necessary and to put the material in more permanent form suitable for future publication.

6. Meeting of Advisory Board (Fall 1966)

After the second summer session, the achievements of the program will be evaluated by the Advisory Board. The preparation of a final report on the program will be a major task in which the assistance of the Board will be invaluable.

7. Summer Teacher Training Institute (1966)

The possibility of conducting a Training Institute at Rensselaer or some other institution during the summer of 1966 for future teachers of the course is being investigated. This would be a separate project. No planning of content or estimate of cost for it is included in this proposal.

B. Cooperation with Other Agencies

We intend to maintain cooperation with a number of groups who are engaged in the development of science materials for elementary schools or in the creation of college courses which have goals similar to ours. One such group is the American Association for the Advancement of Science; it is represented on our Advisory Board through the person of Arthur Livermore. The Minnemast project, which is attempting to develop both elementary school science materials and preservice teacher training courses, has shown considerable interest in our proposal. James Werntz, science director of Minnemast, has attended some of our planning sessions and has agreed to continue to serve in a consultant capacity. Two of our Advisory Board members also serve on the Steering Committee for the University of Texas project, a separate effort intending to produce a resource book and laboratory exercises for a physical science course. We also intend to establish contact with the Educational Services Incorporated elementary science service and film studio.

C. Working Environment

The results achieved by the members of the working groups in summer sessions will depend to some extent on the environment provided for them by the host institution, in this case Rensselaer Polytechnic Institute. Three aspects of this environment are of particular importance: (1) the intellectual and educational background of the institution, (2) the physical facilities which may be made available in the institute plant, and (3) the recreational and cultural opportunities, which are available in the surrounding countryside to the workers and their families.

Rensselaer has long been known as a major institution for education in science and technology. It is not so well known that it has also a considerable background in educational research and experimentation. A list of current and recent educational research programs as Rensselaer, given in Appendix IV, illustrates this point. This list was prepared by the Office of Institutional Research which is an Office of the Administration which was organized to promote and assist the faculty in developing educational research programs.

Physical facilities (offices, conference rooms, shops, etc.) are available for the summer sessions in the new quarters of the Physics Department in the adjoining Rowland and Jonsson Laboratories on the Rensselaer campus. A detailed description of these facilities will be found in Appendix IV. Housing for visiting participants and their families is available in dormitory rooms with private bath, in nearby motels, and in furnished rental apartments in the vicinity. The Housing office of the Institute Administration is well equipped in knowledge and experience to assist visitors in satisfying their housing needs.

Troy is situated in the metropolitan center of the Capital District. It is also close to the resort areas of the Berkshires and the Adirondacks. Excellent facilities for golf, tennis, swimming, camping and hiking are available in Troy and the vicinity. Cultural activities in the area are listed in Appendix IV.

D. Cost Estimate (May 1, 1965 - October 31, 1966)

Salaries and Consulting Fees

1. Equivalent of 3 full-time persons for one academic year, including the Director at 1/4 time.	$ 40,500
2. Consulting fees for 5 teachers for 20 days per academic year (excluding Advisory Board Meetings) at $50/day	5,000
3. Consulting fees for visiting experts at $75/day	1,500
4. Summer Conference - 1965 18 persons at an average of $1500/mo. for two months	54,000
5. Summer Conference - 1966 14 persons for two months (same average salary as above)	42,000
6. Director's secretary (1-1/2 yrs. at $4000/yr.)	6,000
7. Equivalent of 2 typists for 1 year at $3200/yr.	6,400
8. Two laboratory technicians (graduate students, one in physics and one in chemistry) at $300/mo. for 15 months	9,000
Travel and Subsistence	
1. Advisory Board 8 members x 6 meetings (average $100)	4,800
5 science teachers x 4 meetings (average $100 travel + $30 subsistence).	2,600
2. Summer Conferences 1965 - 14 conferees x ($100 travel + $300 dislocation allowance)	5,600
1966 - 10 conferees x ($100 + $300)	4,000
3. Travel - communication and cooperation with other agencies	2,500
Supplies, Services, Preparation of Reports, etc.	
1. Development of experimental materials, summer sessions. Services of machinists, draftsmen, audio-visual personnel, etc.	8,000
Materials and Supplies	6,000
2. Development of experimental materials, academic year. Services and supplies.	6,000
3. Published books for conferees and students in trial classes	1,500
4. New written materials, documents and reports	5,000
5. Experimental kits for students in trial classes	5,000
Communications (telephone, correspondence, etc.)	1,500
Total Direct Costs	216,900
Indirect Costs (15%)	32,535
Total	$ 249,435

Notes on Cost Estimate

Most of the items in the Cost Estimate are self explanatory, but some require further explanation as follows:

Salaries and Consulting Fees

Item 1: This item provides for 3 persons at R.P.I. and 9 persons at their home institutions (12 total) released 1/4 of their academic time for one academic year at an average academic year salary of $13,500. Persons away from R.P.I. may be treated alternately on a consulting basis or released time basis, depending on circumstances and time given to the project. The actual calendar time would be the academic months from May 1965 through October 1966, but the equivalent time is listed for one academic year.

Item 2: This item provides some renumeration for the trial teachers who would probably carry out this activity in addition to their regular academic duties.

Item 3: This item, based on $75 per day, is a daily rate equivalent to $1500 for a working month of 20 days. The $1500 per month is based on 1/9 of an average salary of $13,500 for an academic year.

Travel and Subsistence

Item 1: In this item the average allowance for the trial teachers who attend Advisory Board Meetings ($130) is higher than that for Board members ($100). There are two reasons for this. At least two of the Board members are local and will have no travel expense; and the Director may occasionally wish to keep a teacher an extra day for discussion of his program.

Item 2: Travel and subsistence are not required for conferees from R.P.I. There will be at least four of these in each summer session.

Supplies, Services, etc.

Item 3: A library of books, largely paperbacks, will be necessary for the use of the conferees. A number of copies of each will also be necessary for reference by the students in the trial classes during the academic year.

Items 4 and 5: Each teacher of a trial class will be supplied with sets of the written materials developed during the summer session for use by his students. The same is true for experimental kits.

APPENDIX C-1

Questions to Test Background of

Students in Physical Science Courses

Questions to Test Background of Students in Physical Science Courses

__To the Student:__ These questions are being given to you by your professor in cooperation with a group of people who are about to design a new course in Physical Science for non-science majors. In order not to make the course too hard or too easy we need to have on record some information about the background preparation of students who take such a course. We are very grateful to your professor and you for giving us this information. If you have any suggestions or comments that you think would be useful to us, please add them at the end.

Whenever you don't know the answer, leave a blank.

__A. Vocabulary:__ Tell as briefly as possible what each of the following means to you:

1. horizontal
2. vertical
3. linear relationship
4. chemical compound
5. viscous
6. permeable
7. normal to
8. precipitate
9. convex side
10. a thermal effect
11. sine
12. cosine

__B. Mathematical background:__

1. Express each of the following in some other way.

a. 10^2 ____________________ d. $16^{1/2}$ ____________________

b. 10^{-2} ____________________ e. $\frac{3}{1/2}$ ____________________

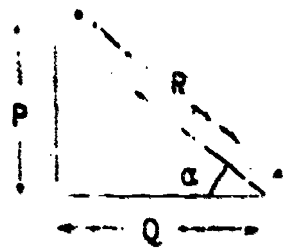
c. 3.251×10^3 ____________________

2. What is the value of x in the following equations?

a. $2x = 4$ d. $\sqrt{x + 6} = 4$

b. $\frac{2}{3}x = 4$ e. $\frac{330}{x} = 11$

c. $3+x = 4$

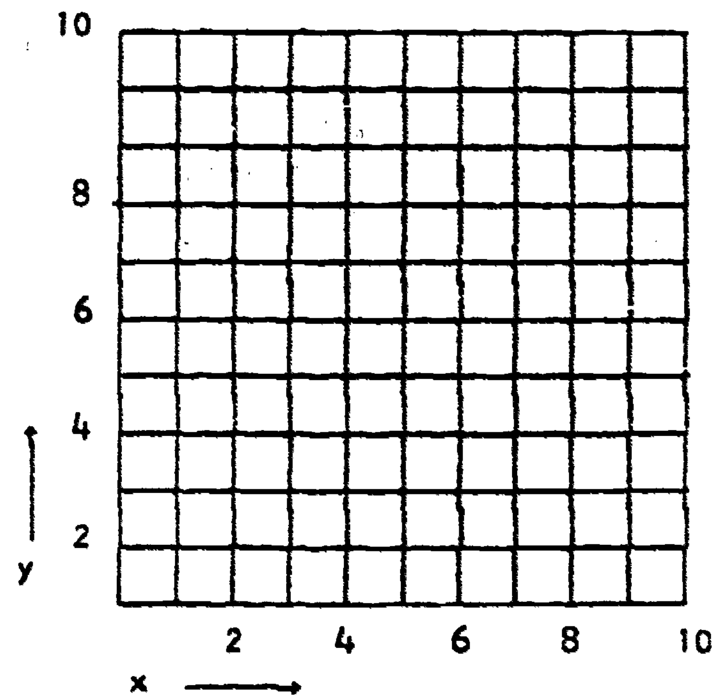
3. 

Express the following functions of α in terms of P, Q, and R: sine, cosine, tangent, cotangent

4. Plot the values given in the table on the grid shown to the right and connect the plotted points to give a graph.

x	y
0	2.0
1	4.0
2	5.0
5	7.5

x	y
7	8.5
10	9.8



C. Observation: Which weighs more, a pint of milk or a pint of cream? How do you know?

D. Interest: Check the phrase or phrases that describe how you felt about this course before beginning it.

_____I was going to enjoy it and do well in it.
_____I might enjoy it but not do well in it.
_____I would dislike it, but do pretty well in it.
_____I would dislike it and do badly in it.

_____It would be useful to me in my future work.
_____It probably wouldn't be useful, but since it was required there must be some purpose in it.
_____It probably wouldn't be useful but taking it would be worthwhile for my general background as a person.
_____I couldn't see how it could be useful and therefore thought taking it was a waste of time.

PLEASE ADD ANY COMMENTS YOU MAY WISH TO MAKE ON THE BACK OF EITHER SHEET.

APPENDIX C-2

Tables of Contents of all editions
of the Text and of the Supplementary
Chapters

AN APPROACH TO PHYSICAL SCIENCE

PRELIMINARY EDITION

1965

Rensselaer Polytechnic Institute

Troy, New York

TABLE OF CONTENTS
Volume I

LIST OF EXPERIMENTS

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Volume 2

LIST OF EXPERIMENTS

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Volume 4

LIST OF EXPERIMENTS

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Volume 5

LIST OF EXPERIMENTS

AN APPROACH TO PHYSICAL SCIENCE

SECOND PRELIMINARY EDITION

1966

Rensselaer Polytechnic Institute

Troy, New York

Volume 1

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Volume 1

LIST OF EXPERIMENTS

AN APPROACH TO PHYSICAL SCIENCE

SECOND PRELIMINARY EDITION

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AN APPROACH
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SECOND PRELIMINARY EDITION

1966

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Volume 3

AN APPROACH TO PHYSICAL SCIENCE

THIRD PRELIMINARY EDITION

John Wiley and Sons, Inc.
New York, New York

Volume 1 1967

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Volume 1 1967

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Volume 2 1968

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Final Hard-Cover Text

An Approach to PHYSICAL SCIENCE

Physical Science for Nonscience Students

PSNS Project Staff

JOHN WILEY & SONS, INC.
New York London Sydney Toronto

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Chapter 4 Interference of Light

Chapter 5 Crystals In and Out of the Laboratory

Chapter 6 What Happened in 1912

Chapter 7 Matter: A Closer Look at Differences

Chapter 12 *Electric Charges in Motion*

Chapter 13 *Models of Atoms*

Chapter 14 *Ions*

Chapter 15 *The Nature of an Ionic Crystal*

Chapter 16 *Molecules*

Chapter 17 *Nonionic Materials*

Chapter 18 *What It Is All About*

An Approach to Physical Science:

Supplementary Chapters

PSNS Project Staff

John Wiley & Sons, Inc.
New York . London . Sydney . Toronto

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APPENDIX D-1

Reports of Advisory Board Meetings

INFORMAL REPORT OF THE PSNS ADVISORY BOARD MEETING
November 26 and 27, 1965

at the American Institute of Physics, New York City

Present: L. G. Bassett, A. N. Holden, C. C. Price, R. Resnick, E. A. Wood, R. L. Sells, A. A. Strassenburg, and, as guests on November 26, R. Rickert and R. Sakurai.

Absent: F. R. Kille, A. H. Livermore.

This report will not be in chronological order, as proper minutes of a meeting would be, but will be a record of notes on the meeting.

Decisions concerning future plans on which the advice of the board was sought and agreement was reached will be preceded by an asterisk. I would especially appreciate your directing your attention to these points and letting me know if you think I have misinterpreted the advice of the board.

A report of the present financial status of the Project was given by Bassett. Although cost of equipment and of production of written materials for the current academic year exceeded the amount allotted in the budget, cost of services and supplies during the summer of 1965 was appreciably less than anticipated. Total expenses for the period covered by the first part of the grant have been slightly less than anticipated, and those for the second period of the grant may be slightly more. The second

part of the grant has been allotted in full and is available for use at RPI.

Cost of equipment for the current academic year will average about $15. per student. A list of 41 people who have expressed an interest in the course was distributed by Bassett.

*It was the consensus of the meeting that the number of colleges trying the course during the academic year 1966-67 should be limited to those for whom the Project could afford to supply equipment. This would probably mean a number less than 20, During this academic period students should be asked to buy the text material. Teachers wishing to try the course during the academic year 1966-67 (except those now trying the course who wish to repeat it) should be required to agree to the following conditions:

1. The course, including experiments, would be taught over a full academic year.

2. The instructor would agree to come to RPI for a two-week briefing session August 23 to September 3, 1966. His traveling and subsistence expenses would be paid by the Project, but no stipend would be paid to the instructor.

A brief report of last summer's writing conference was given by Wood. In addition to writing the chapters which are now coming out, each of which turned out to be one

person's responsibility primarily, the staff reviewed and evaluated a large number of films. A list of films recommended for use with the course and designated for use with particular chapters was supplied to instructors. Trial of some of the experiments by students at Geneseo was very helpful. Pressure of the close deadline for trial during 1965-66 was probably more beneficial than detrimental to the success of the summer session.

Specific criticisms of text material were made by Holden, who felt that the headings listed in the Table of Contents were cute and uninformative, and by Strassenburg, who felt that Chapter 4 failed to carry through on some of the important points that it almost, but not quite, made.

Discussion of films included a suggestion by Resnick that we make a wider survey of available films, including some Canadian ones, and that someone be assigned to "line up films" to be considered this summer in advance of the opening of the summer session. The Chemstudy film on crystal structure was recommended by Price. Holden suggested the possibility of using films during briefing sessions or Teachers Institutes to suggest good teaching techniques by example.

*It was agreed that the production of films should not be undertaken by the PSNS Project either under the present

grant or in the period to be covered by the next proposal, which would presumably terminate October 1, 1968. It was recommended that suggestions be given to Don Herbert for desirable films and that he be asked whether kinnies of his television programs are available and on what basis.

The question of evaluation of the course was discussed and the advisability of asking the help of a professional evaluation service was considered. Betty Wood was asked to discuss with Professor Zacharias his experience along these lines (this has now been done and the result is that he feels an organization such as ETS is useful for printing examinations which we design and grading them. Grades arrange students in a one-dimensional array. What they derive from the course is not expressible in a one-dimensional array. Evaluation is something we don't know how to do. What we do know is that students who have done some things can then do other things better than they could before).

*It was felt that the Project is not yet ready for a publisher. Lew Bassett was asked to investigate the abilities of printers in the Albany area to handle a somewhat enlarged printing of text materials next summer.

*The handling of equipment supply, on the other hand, should be placed in the hands of professionals as soon

as possible. Betty Wood volunteered to contact equipment people and arrange for bids for handling supplies for the academic year 1966-67.

*It was felt that the time had come for issuing the first newsletter about the Project. This initial letter should be one appropriate for use in answering the many letters that are coming in asking for information about the Project and the possibility of using the course in the near future. Betty Wood volunteered to produce the first draft of such a letter for approval by Lew Bassett, Duke Sells, and Arnold Strassenburg.

Reports of current use of the course were given by Russell Rickert and Dick Sakurai, who brought written notes for distribution to the board. These will therefore not be included with this report, but notes from Earl Carlyon are included herewith.

Reports of the PSNS Project will be given by Bassett and Wood to meetings of chemists and physicists respectively this winter.

*It was agreed that the following meetings should be arranged:

1. A meeting of trial teachers on January 27, 1966 in New York City for the purpose of exchanging ideas and discussing experiences they have had with the course.

2. A meeting of the 1966 summer staff very early in the spring, probably in April.

3. A feedback session for the trial teachers at RPI during the first week or two of the Project. This session would last from 3 to 5 days, and its results would form a basis for revising the Main Stem material of the course. It was suggested that H. M. Landis be in charge of this session and of the analysis and organization of the results of this session.

It was announced that Arnold Strassenburg had agreed to act in the capacity now filled by Betty Wood for the period of the Project for which an extension proposal is about to be made, namely October 1, 1966 to October 1, 1968. He distributed a suggested outline of a proposal covering this period.

*The outline, entitled "Suggestions for activities prior to and during a two-year extension of PSNS grant," which was distributed by Strassenburg, received the general approval of the board.

*The following list of people who were PSNS staff members last summer were approved by the board for our invitation to participate in the Project during the summer of 1966. In addition, it was suggested that an attempt be made to enlist those people whose names are marked with an asterisk at the end of the list.

Banewicz	(f = full time)	Resnick	(e = eighth time)
Bassett	(f)	Rickert	(f)
Bunce	(h = half time)	Sakurai	(f)
Campbell	(h)	Sells	(f)
Carlyon	(f)	Smith	(f)
Landis	(f)	Westmeyer	(f)
Racster	(f)	Wood	(f)
Read	(f)		

*Don Holcomb (as fully as possible)

*Dick Crane (as fully as possible)

*Melba Phillips (as fully as possible)

*Tom Lippincott, Ohio State

*Richard Yalman, Antioch

*(Two others to be suggested by Price)

*Walter Gensler

*Ted Benfey

*Joe Levinger

*Bill McConnell, Webster College (Walton says he'd be good at revising Main Stem)

*Fred Tabbutt (Reed)

INFORMAL REPORT OF PSNS ADVISORY BOARD
MEETING OF MARCH 11 AND 12, 1966, AND OF SUBSEQUENT ACTIVITIES.

Present: L. G. Bassett, A. Holden, W. Boyd (for F. R. Kille), A. H. Livermore, R. Resnick, A. A. Strassenburg, J. H. Werntz, E. A. Wood.
Absent: C. C. Price, R. L. Sells

The following colleges were approved by the Board as Trial Colleges for the academic year 1966-67, in some cases with the proviso that they limit enrollment to less than that mentioned in their applications:

Arkansas State College	Meramec Community College
Bloomburg State (Pa.)	Harford Junior College
Fairleigh Dickinson, Madison, N.J.	Nassau Community College
Colorado College	Newark State Teachers College
College of St. Benedict	Catholic Diocese of Brooklyn (in-service)

Since the meeting, several additional colleges have been accepted, to bring the number of students approximately to 2000, the number we think we can handle, provided the grant requested for the next two-year period is approved. The letter sent to each college informed them of the necessarily provisional nature of our commitments. A copy of one such letter is enclosed herewith.

Applicants that are now being turned away are being encouraged to apply for participation during the academic year 1967-68. A copy of a letter to one of these is enclosed herewith.

The complete list of trial colleges as it now stands is enclosed, as well as a map showing their geographic

distribution. Pertinent information tabulated includes the year of trial. The 1965-66 colleges are thus included, whether or not they plan to repeat the course in 1966-67.

Your attention is called to the fact that the University of Texas is now one of the 1966-67 trial colleges, thus filling the need for a large state university.

The second item of business was to consider potential equipment suppliers for 1966-67. During the meeting conflicting opinions were expressed concerning the reliability of Macalaster. Alternatives favorably mentioned were Will Corporation and Damon Educational. After the meeting further adverse reports concerning Macalaster and favorable comments on Damon from ESI sources resulted in a visit to Damon by Betty Wood on March 22. She was favorably impressed not only by the ability of Arthur Vash and Wesley Perry to understand what we are trying to do and their willingness to handle soda-straw and rubber-band items, but also by the suitability of their physical plant for our job.

Duke Sells and Earl Carlyon visited the Will Corporation and found that they were not interested in providing the PSNS equipment. Accordingly, with the approval of Lew Bassett and Duke Sells, Betty Wood notified Arthur Vash on April 11 that we wanted Damon Educational to handle the job.

On April 22 Arthur Vash and Wesley Perry will meet at R.P.I. with Lew Bassett, Duke Sells, Earl Carlyon and Betty Wood to discuss as fully as possible the equipment plans for 1966-67 and get Damon started on some items we are sure to want.

A third item of business at the meeting was the Proposal for continuing support of the Project for the period October 1, 1966-October 1, 1968. This was presented by A. A. Strassenburg who will be an Associate Director and Chairman of the Advisory Board for that period. The plans include extended trial during the winter of 1966-67, with the Project still supplying equipment and subsidizing texts, further revision of materials during the summer of 1967, a very much extended "trial" of the course (essentially open to all applicants) during 1967-68 and preparation of the "final" form of materials for a publisher during the summer of 1968. A separate grant for an eight week Teachers' Institute during the summer of 1967 will be requested. It is not properly part of a course development project.

The question of evaluation was discussed. There was not general agreement concerning the value of testing to determine the extent to which the Project had achieved its objectives. However, the Board was not opposed to requesting the assistance of a professional testing organization in evaluating any change in attitude on the part of the students. Subject matter testing is to be the responsibility of the PSNS staff. J. Werntz recommended that any attitude test be sent to the members of the Advisory Board so that they might guess what answers the students would give at the time the test was administered (before, during and after the course).

He anticipated that the Board would be able to guess the average results of the tests, thus indicating that the expense of designing and administering them was an unnecessary expense.

A. Holden suggested that enlisting a chemist from Geneseo for the PSNS staff might result in adoption of the course as a full-year course there, rather than a half-year course, taught only by the Physics Department as it is at present. (Duke Sells has now been consulted on this point. The science requirement at Geneseo is two semesters and the students may choose among four one-semester courses: Biology, Geology, Physics and Chemistry. Most of them avoid Physics and Chemistry. He sees no hope of arranging to have them take two semesters of Physical Science.)

A. Holden suggested enlisting Dorothy Montgomery as a consultant since she has been systematically reviewing films for AAPT.

Betty Wood, on behalf of Frank Kille, gave a report of the organization of activities in the New York State Department of Education, where increasing attention is being paid to science education.

The PSNS staff for the summer of 1966 was reported to consist of the following members, as of March 12. (Figures in parentheses indicate proportion of eight weeks to be spent on the Project.)

Carlyon	(1)	Bunce	(1/2)	Strassenburg	(1/2)
Sells	(1)	Sakurai	(3/4)	Rqcster	(1)
Resnick	(1/10)	Westmeyer	(3/4)	McConnell	(1/3)
Bassett	(1)	Clark	(1)	Holcomb	(1/4)
Wood	(1)	Read	(1/2)	Levinger	(1/2)
Landis	(1)	Smith	(1/2)		

Since the meeting an additional member of staff has been added: Robert Stoeckley, an astro-physicist at R.P.I. who will be with us half time.

All members of the staff except Resnick, Read, McConnell and Levinger met at R.P.I. on April 6 and 7 and the priority order for work to be done during the summer of 1966 was discussed. It was agreed that revision of the early chapters with addition of questions, problems and perhaps further experiments was the highest priority item because of printing deadlines. Matters to receive attention during revision are:

A. Style and tone.

B. Experiments (Uniformity of distribution.)
   (1) Those in series with the development of the text.
   (2) Those not in series. These can be more open-ended.

C. Questions and problems. (More needed, early on.)

D. Pace and choice of content. Main stem thinning.

E. Level of treatment. Apparently about right as it is.

F. Order of topics; integration of disciplines.

Optional Packages were assigned as follows:

A. Geometrical Optics - Carlyon

B. Sound - Sells

C. Circuits - Read

D. Avogadro's Number - Westmeyer

E. Acids and Bases - Color Indicators - Smith

F. Astronomical Measurement - Stoeckley

G. Gravity and Satellite Orbits - Stoeckley

H. Magnetism - Holcomb

I. Biological Molecules - Bunce

J. The Nucleus - Levinger

K. Organic Structures and Reactions - Clark

Subsequently S. Bunce pointed out that revision of the Main Stem material on covalent substances should be undertaken prior to the Optional Packages on organic and biological substances.

There was discussion of the "Ground Rules" for Optional Packages. Three catagories of subject type were suggested.

1. Subjects not taught at all in the Main Stem which teachers want to teach (e.g. The Nucleus.)
2. Subjects briefly mentioned in Main Stem which can profitably be handled in greater depth (e.g. Magnetism.)
3. Subjects which illustrate the application of principles introduced in the Main Stem (e.g. Gravity and Satellite Orbits, Circuits.)

Jim Landis agreed to act as editor of the Resource Book for Instructors as an extension of his responsibilities for organizing this year's feedback.

Categories of material for inclusion in the Resource Book for Instructors were suggested as follows:

A. "Threads", in the sense of the original project proposed. Emphasis of these at the beginning, perhaps with a "flow sheet" showing their repeated occurrence in the course.

B. Suggested films, discussion.

C. Discussion of experiments and demonstrations.

D. Theory in greater depth.

E. Examination questions and homework problems. Sakurai.

F. Supplementary Reading list (fully annotated.) Rickert.

G. Good projects for the students to chew on over an extended period of time outside of class.

Several of the staff members will begin work prior to the official opening date, June 20, 1966.

Elizabeth A. Wood

Elizabeth A. Wood
Murray Hill, N.J.
April 18, 1966.

Copies to: L. G. Bassett
A. Holden
F. R. Kille
A. H. Livermore
C. C. Price
R. Resnick
R. L Sells

W. Boyd } N. Y. State Dept. of Ed.
A. Lierheimer
A. A. Strassenburg
J. H. Werntz
R. Paulsen (NSF)

PSNS Advisory Board
American Institute of Physics
335 East 45 Street
New York, New York 10017

February 20, 1967 and
February 21, 1967

The meeting of the PSNS Advisory Board was called to order at 10:05 am on February 21, 1967, in the Compton Board Room of the American Institute of Physics, by Dr. A. A. Strassenburg, Chairman of the Advisory Board. All members of the Board were present except Professor Charles Price of the University of Pennsylvania. (A list of the Board members is attached.) Dr. Strassenburg announced that 8 bids from publishers for the PSNS text materials had been received, and that 2 companies had requested permission to submit their bids late. They had been given permission to do so, but had been told that this would necessarily mean that they would not receive the same type of consideration as could be afforded to those whose bids were available to the assembled Board at the time requested.

Proceeding to the Agenda (copy attached), the following reports were made:

1. Review of Summer Output (1966): E.A. Wood

Activities for the summer of 1966 included a week-long feedback session at Rensselaer Polytechnic Institute, during which the trial teachers gave information regarding their reactions to the course, and those of their students. The mainstem text was then revised in consonance with the results of the feedback, which indicated that attention should be paid to the course as a whole, especially with reference to the pacing of the lectures, etc. A table describing a reasonable method of teaching the course -- within various frameworks -- for example, a 3-credit course including 2 lectures and 1 2-hour laboratory session per week -- was prepared. New experiments were devised where needed. There also had to be a drastic revision of Chapters 4 and 14. The teachers felt that the treatment of X-ray diffraction in Chapter 4 had been heavy and was rather difficult, especially the mathematical derivation of diffraction. A paperback book on chemical bonding by Sisler, which had been used as a substitute for Chapter 16, was replaced by new material.

Last year, most teachers had only progressed as far as Chapter 8, none further than Chapter 12. Unfortunately, this indicated the possibility that there was too much material in the mainstem. It was determined that the second revision should eliminate a considerable amount of material. Since most teachers were not able to get to the last five chapters of the book, there was virtually no feedback regarding this final section, and this was forseen as a handicap in preparing the third edition.

During the summer of 1966, work was begun on a Teacher's Guide. Previously, advice to teachers had been in the form of letters of guidance from Mrs. Wood. Last summer, a loose-leaf guide was prepared, but this is incomplete. Periodically during this academic year, additional materials are sent to trial teachers. The author of each chapter of the mainstem acts as the author of the corresponding section of the Teacher's Guide. All Guide material is collected and edited by Professor Harry M. Landis of Wheaton College. A major project for the summer writing session

in 1967 is the preparation of a full-fledged Teacher's Guide. It was felt that such a guide should also include general aids for using the course as a whole, such as information as to what portions of the work may be skipped in order to shorten the course if necessary, but still maintain its overall integrity. It seems essential that some aspect of every topic or chapter must be covered for the sake of continuity.

Some members of the Board felt that the Teacher's Guide should admonish teachers not to hurry through the course, merely for the sake of completing the entire "book", but others questioned the advisability of allowing teachers the possibility of concentrating on one segment of the material and neglecting the remainder. Perhaps a stern revision of the mainstem is really a better solution to the teachers' problems of dealing with the length of the coursethan trying to alter superficially the course "second-hand" by means of advice given in the Teacher's Guide.

As the Teacher's Guide now stands, there is material for each chapter through 12. Mrs. Wood is working on Chapter 14 guide materials. However, the guide for each chapter is by no means complete.

The plans for the 1967 summer writing session include: review of the mainstem text; formalization of the Teacher's Guide; completion of a full set of Supplementary Chapters.

2. Report on Present Status of PSNS Materials: L. Bassett

The mainstem text is now in its Third Preliminary Edition, and consists of 17 chapters. It is being sent out to those who request it. There is some indication from the trial teachers that they will not get to Chapter 13 this year, since they have indicated almost no need for the laboratory supplies for the later chapters. The largest number of teachers is giving a course with 2 hours of lecture and 2 hours of lab per week, for 3 credits; some present a 4-credit course with 3 hours of lecture and 2 hours of lab. One supplementary chapter is ready for trial this spring; others are in various stages of preparation.

Dr. Bassett distributed a schedule of expenditures. This is a temporary budget prepared solely for the information of the Board as to the status of PSNS funds and other assets. (Copy attached.)

Both publishers and members of the Board have questioned the viability of the prospective publishing schedule. A slower pace has been recommended by several publishers. Professor Resnick indicated a similar opinion in a letter to Dr. Strassenburg following the January 10 publishers meeting. The slower schedule would provide for a third preliminary edition in the fall of 1967 which could serve for 2 years. The hard-bound final edition would follow. This 2-year period would provide ample time for feedback based on the entire revised third edition of the course; this third edition would hopefully take into account the feedback results already obtained, and other feedback based on the trials of this academic year. In answer to doubts expressed regarding the funding over a protracted period, Professor Resnick pointed out that if the hard-bound edition came out in the spring of 1969, there should be no financial difficulty, even though the present funding will terminate in the fall of 1968. Mr. Livermore added that after August, 1968, the financial responsi-

bilities should be assumed by the publisher to whom the contract is awarded.

3. Report on Feedback Session, Fairleigh Dickinson University, February 3-4, 1967: R. L. Sells

The recent feedback session indicated that many teachers had only completed the mainstem through Chapter 8 at mid-year. This would seem to indicate that it would be possible for them to complete 16 chapters in 2 semesters. There was, however, some doubt expressed that his projection would prove valid.

Various suggestions for improving the course were made by the teachers participating in the feedback session: 1) reshuffle some chapters (e.g. invert the order of 4 and 6); 2) delete some chapters; 3) add material -- there was more eagerness to have material added to the course than to have it deleted; 4) balance the experiments against the text materials (this seemed to some an obvious chore for the Teacher's Guide).

Several teachers reported difficulties in their lab work but as there are only one or two experiments which require laboratory facilities (e.g. gas supply for operating a Bunsen burner) it was concluded that the major problem in many schools is in acquiring sufficient space for the lab sessions. These sessions must be held in a room where there are such simple facilities as running water. Many schools are reluctant to provide the necessary facilities, however basic. It was observed by several members of the Board that the fact that the requirements of the PSNS course demand attention by administrators to the needs of an experimentally oriented course is beneficial to the cause of experimental physical science. Perhaps, if enough pressure is exerted, the trend away from the experimental approach will be reversed.

Dr. Kille stated that there are now very often amendments in money bills passed by the federal government which provide for funds to create space for facilities. PSNS contributions in the field may provide a necessary stimulus toward the formalization of recommendations by state departments of education regarding the amount of space and time a given institution must allow for physical science courses.

Dr. Bassett pointed out that the 1967-68 academic year will require institutional cooperation in providing the necessary equipment for the PSNS course, since the funds now being used to subsidize schools in acquiring the PSNS equipment will no longer be available. Dr. Kille remarked that it will be possible for the schools to obtain federal aid for equipment. Mrs. Wood suggested that Damon Educational, Inc. should be apprised of this potential aid. They should assume the role of educating the educators, in order to increase their market. Dr. Kille informed the Board of the existence of the Elementary and Secondary School Act - Title V designed to improve state education departments, and of the New York State Science and Technology Foundation.

Some schools had found their own solutions to the problem of completing the lab work for the course which involved instituting rather unorthodox methods of scheduling. Professor Sells had good results at the NYS College at Geneseo using undergraduate student assistants in the labs.

The possibility of using filmed or taped instruction for the labs was raised. Mrs. Wood felt that such methods are actually contrary to the nature of the course, but that the teachers definitely <u>do</u> need technical advice on how to operate the course, especially the experimental aspects of it. Professor Werntz agreed, and added that he felt it was advisable to go slowly in improving the fare offered physical science students. The innovation of a non-encyclopedic course is a great advance in itself. However, he suggested that it would be wise to select an imaginative publisher, not one who will only produce a book and materials which will make the newly conceived style of this course seem to conform to old patterns.

Professor Holcomb remarked that some teachers had questioned the necessity of <u>discoveries</u> in order to maintain the momentum of the course. The teachers apparently do not object to <u>telling</u> their students what will happen in a given experimental situation, and in many cases feel that this is wiser than to run the risk of a student drawing conclusions from miscarried experiments. There is a delicate balance between completely unstructured exploration and "cookbook" laboratories. We must strive to achieve this in the text, and help teachers to understand it through the Teacher's Guide and summer institute.

<u>4. Future Plans: A. A. Strassenburg</u>

<u>A. Publication</u>: The scheduling of publication of the final version of materials depends to a large extent upon the publisher selected, but a revision should be prepared for use during the 1967-68 academic year, possibly for use during the subsequent 2-year period. Thereafter, a new revision based on trials yet to be made and feedback yet to be gathered will enable the preparation of the hard-bound edition by Fall, 1969.

<u>B. Publisher</u>: In dealing with publishers and preparing plans for publication, various problems have come to light regarding financial arrangements, with respect to the requirements of the NSF and of RPI. The questions regarding royalty arrangements and copyrights must be looked into. Although many contributions of information were made, no definitive conclusions could be reached, due to lack of specific legal information.

In preparing for the afternoon session Dr. Strassenburg called to the attention of the Board several letters and other materials: letter from the American Textbook Publishers Association inviting publishers to the January 10 briefing session; a list of publishers present at that briefing; 3 anonymous reviews solicited by the Scott, Foresman Company; letter from Professor Resnick pertinent to the proposed publication schedule; letters from Oxford University Press, Houghton-Mifflin, and the Norton Company, received subsequent to the publishers' briefing.

The meeting was adjourned at 12:20, to be re-convened after lunch.

The PSNS Advisory Board meeting was re-convened at 2:30 pm, February 21 in the Compton Board Room at the American Institute of Physics. The members of the Board proceeded to consideration of the proposals for publication of the PSNS materials. The Board was informed by Dr. Strassenburg and Mrs. Wood that information regarding the wishes of the NSF regarding financing and provisions for revision, royalties, copyrights, and similar matters had been raised by publishers' representatives, and that no definite answers could be given at that time (January 10). It is therefore necessary for the Board to take this lack of information into account in considering the financial arrangements offered in various proposals.

The publishers' representatives were also informed as to the position of Damon Educational, Inc., in producing the laboratory materials. They were told that co-operation with Damon would not be imperative, but that the PSNS administrators would consider a liaison with Damon favorably. It was felt that there should be some joint advertising and marketing carried out by the publisher and Damon, but there were no demands made that Damon be the apparatus manufacturer selected by the publisher. Communication with Damon after the publishers' meeting revealed that Damon would prefer to sell the laboratory materials and apparatus to the selected publisher who would then market the whole package. Such an extreme is not desirable, but some financial arrangement would seem necessary, because Damon cannot handle a large market independently without the assistance of a publisher's contacts and marketing facilities.

Professor Holcomb remarked that at the publishers' meeting, representatives of Prentice-Hall were concerned as to the amount of control the PSNS administrators would exert on the publisher's services. The representatives at the January 10 meeting were definitely led to have a feeling of freedom regarding the actual production of the text and materials, especially with regard to illustration, graphics, style, etc. Certain flexibility can be granted, but not regarding such matters as copyediting the text to fit the usual standard format of separate experiments and text, or otherwise altering the general style to make this text no different from every other physical science text.

It was noted that one publisher pointed out the possibility of a penalty clause in the publishing contract, which would provide that the publisher would pay a given amount per day to PSNS for delay in production.

The statement was made that it was necessary to select a publisher who would inspire confidence in prospective users of the course.

The Board then proceeded to individual consideration of the publishers' proposals.

Tuesday, February 21, 1967
PSNS Advisory Board Meeting
Re-convened at 9:00 am.

After additional time spent reading and examining the proposals, the Board reviewed their reactions to the various proposals. This was done by means of a blackboard chart, which checked the characteristics desired by the Board against the offers in each category, made by each publisher. In this way, 4 of the 8 publishers were eliminated. In order to proceed to a final decision, two steps were agreed upon by the Board:

1. Dr. Strassenburg must consult with the NSF to determine what its guidelines are regarding financial arrangements, etc.

2. On a given day to be selected in the future, each of the 4 remaining publishers will be invited to send a representative to appear individually before the assembled Board, so that the Board can obtain additional information.

After these two steps have been taken, the Board will meet to make a final decision regarding the selection of a publisher.

After lunch on Tuesday, two other matters were discussed by the Board:

1. The growth in the number of schools using the course.

While it had been assumed that the growth of the course would proceed at a good rate without additional stimuli, it now appears from the observations made by Dr. Strassenburg and Professor Bunge during the previous 2-day session reviewing applications for the summer institute that it may be wise to publicize the course more widely. It was therefore decided by the Board to prepare a brochure describing the PSNS project, course and materials, and that this brochure should be mailed to the 400 interested parties on the existing mailing list. Hopefully, this will accrue enough additional publicity to increase the number of colleges presenting the PSNS course to 40-75 schools for the academic year 1967-68. Mrs. Wood will draft the brochure. It will be reproduced and mailed through RPI.

2. Evaluation of the course.

There was discussion about evaluation of the course, but no decision was taken by the Board. Although there has been considerable communication in this regard with ETS (Educational Testing Service), negotiations have dwindled. Suggestions were made that possibilities for evaluation of the course continue to be explored with other agencies, and that ETS be re-contacted.

1/18/67

3. Election of Co-director.

The Board voted to invite Professor Walter Eppenstein, Department of Physics, Rensselaer Polytechnic Institute, to serve as co-director of the PSNS project with Professor Bassett of the Chemistry Department, RPI.

The meeting was adjourned at 4:20 pm, February 21, 1967.

Respectfully submitted,

Abigail Peterson

Abigail Peterson

Secretary to
Dr. Strassenburg

AP
3/30/67

PSNS Advisory Board Meeting
American Institute of Physics
335 East 45 Street
New York, New York

February 20, 21, 1967

AGENDA

Monday, February 20, 10:00 am.

1. Review of summer output
2. Report on present status of materials
3. Report on Fairleigh Dickinson feedback session and discussion of reactions from teachers at the trial colleges
4. Discussion of future plans
   a) publication
   b) course trials in 1967-68
   c) evaluation
   d) directors of project

LUNCH at Johnny Johnston's

5. Individual study of publishers' proposals

Tuesday, February 21, 9:00 am.

6. Continuation of proposal study
7. Discussion of proposals and formulation of recommendations for criteria and procedures to observe in making final decision

LUNCH at Renato's

8. Film on Symmetry by Philip Stapp
9. Discussion of policy on "Supplementary chapters"
10. Discussion of problems in producing "teachers' resource book"

ADJOURNMENT before 4:00 pm.

PSNS ADVISORY BOARD

Bassett, Prof. Lewis
Chemistry Department
Rensselaer Polytechnic Institute
Troy, New York 12181

Holcomb, Prof. Donald
Department of Physics
Cornell University
Ithaca, New York 14850

Holden, Dr. Alan
Bell Telephone Laboratories
Murray Hill, New Jersey

Kille, Dr. Frank R.
Associate Commissioner
for Higher Education
New York State Department of Ed.
Albany, New York

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American Assoc. for the
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1515 Massachusetts Ave., N.W.
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Price, Prof. Charles
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Geneseo, New York 14454

Werntz, Prof. James
Department of Physics
University of Minnesota
Minneapolis, Minnesota 55414

Wood, Dr. Elizabeth A.
Bell Telephone Laboratories
Murray Hill, New Jersey

Chairman:

Strassenburg, Dr. A. A.
Division of Education and Manpower
American Institute of Physics
New York, New York, 10017

Estimate of PSNS Financial Status - 1/31/67

Balance 1/31/67 $244,643

Estimated Expenditures

Feb 1967	$ 20,000	(includes Feedback Conference, 2/3-4)
Mar	24,000	(includes Damon-Chap 12 Equip. + Fort Orange - Vol 3)
Apr	24,000	(normal + Damon Chaps. 13 and 14)
May	24,000	(normal + Damon Chaps. 15 and 16)
Jun	26,000	(normal expenses 10,000 + 2 wks SS, $6000 wk + Feedback session, $4000)
Jul	30,000	($6000 + 4 wks SS, $6000/wk)
Aug	30,000	($6000 + 4 wks SS, $6000/wk)
	$ 178,000	

Estimated Balance 1 Sep 1967 $66,600

This balance should carry the Project through Calendar 1967.

See paragraph 3 of GE-8573, Amendmen. 2

Apply for additional funds by 15 Sep 1967 - check this now with Dr. Gortner.

Minutes of

PSNS Advisory Board Meeting

April 11, 1969 — Troy, New York

Present: Lewis G. Bassett
Earl Carlyon (guest)
Walter E. Eppenstein
Alan Holden
Arthur Livermore
Thomas Sears (guest)
Charles B. Stoll (guest)
A.A. Strassenburg
Wayne Welch (guest)
Elizabeth A. Wood

Financial history reviewed by Bassett: NSF removed the expenditure limitations on some funds granted to RPI. As a result, PSNS has had about $63,000 restored to its budget. NSF granted a one-year (to June 1970) extension to allow time to spend these funds wisely. Unexpended funds amounted to $94,000 as of April 1. We need to make some commitments by June 30 so that the uncommitted balance then will be $63,000.

The following activities are proposed for the final year of the project:

1. Evaluation of PSNS course.
2. Completion of supplementary chapters (4 or 5 staff members for 4-6 weeks during the summer of 1969 should be sufficient to accomplish this).
3. Cooperation with Wiley in arranging and conducting short workshops to familiarize prospective teachers with PSNS materials.

Strassenburg briefly reviewed past efforts to arrange for evaluation. $3000 was paid to ETS; relationships with ETS terminated after they refused an invitation to send representatives to RPI to work closely with the PSNS staff during the summer of 1968.

We would like to suggest to Wiley that we share the expenses and work of arranging "workshop" or "briefing" sessions.

We propose to develop a set of transparencies during the summer of 1969. Walter Eppenstein would lead this effort; Earl Carlyon could assist.

We definitely sense a need for some supplementary chapters. Bassett receives an average of two requests a day for the four existing preliminary versions. We still have copies for samples; neither text nor apparatus is available for large-scale use.

Strassenburg reported that three proposals to NSF for PSNS Summer Institutes were turned down. Eppenstein suggested we energize proposals at once for the June 1 deadline. Boothby, Landis, Hollinger, Inglis, Arons, (Mary) Lee Bolton, Strassenburg, were suggested as potential directors. Eppenstein recommends that we suggest supporting staff to the directors. Tom Strickler of Berea

(more)

College, two men from Eastern Kentucky State College, and Shirley Aronson were suggested as excellent candidates.

Supplementary chapters were reviewed by Wood: There was an extensive discussion on the need for supplementary chapters. In addition to efforts to review and clarify the philosophy behind the concept, the Board discussed the merits of each proposed chapter, the total number desired, and how they should be bound. We reached consensus that there should be 5 $\pm$ 1. Binding will be discussed with Wiley; probably all chapters will constitute a single, soft-cover volume. It was agreed that the seven Board Members present would vote for those titles the staff should develop, up to five. The results:

Acids and Bases	0	
Magnetism	4	
Matter in Astronomical Realm	7	
Matter in Earth	7	
Equilibrium	4	
The Nucleus	2	
Avagadro's Number	0	
Biological Molecules	0	
DC Circuits	2	
Geometrical Optics	4	
Matter in the Oceon	1	Suggested by Alan Holden
Matter in the Atmosphere	1	
Strength of Materials	1	

It was decided that the staff should develop those chapters receiving four or more votes.

Bassett on briefing sessions: Project should finance technical staff for briefing sessions, i.e., pay them and their expenses. Time and experience is needed in making arrangements with the schools. Two-day sessions are desirable, therefore it is reasonable that we share the costs. Our proposed budget calls for 20 during academic year 1969-70. It was agreed that these sessions should be called "PSNS Workshops".

Lunch

Evaluation: Wayne Welch discussed his proposal for evaluation of PSNS. He must make some decisions concerning his summer commitments. He will remain at HPP this summer; on September 1 he will move to the University of Minnesota -- they have agreed with his involvement with PSNS.

There was a discussion of Wayne Welch and his proposal following his leaving to make an airplane. It was moved and seconded that we engage Wayne Welch to proceed on the basis of his proposal dated 4/8/69 and approve his proposed budget. Passed unanimously.

Transparencies:

Holden expressed misgivings about the strong effect of too precise images. Some felt that this was not an argument against transparencies but against an excessively formal style of illustration.

(more)

Strassenburg asked Eppenstein to suggest an appropriate scale of effort. Eppenstein suggested 30 to 40 transparencies; the equivalent of two months of work in the summer. The cost (to the school) was estimated at about $250 for 40 transparencies bound in units. Wiley declined to guess at the percentage of schools that would order them. Eppenstein said they are widely used in other subjects.

Strassenburg asked Wiley what they would do with transparencies if the staff had time to develop some this summer. Bassett said he thought the development of them could be supported by the PSNS budget, but there is no point in developing them unless Wiley is going to produce them. Stoll replied that we will know a lot better about the need for supplemental materials in another year. The partial funding of workshops by PSNS funds will take away some of the load on those other Special Fund monies. In another year we could use the money accumulating in the Special Fund to generate supplemental materials -- transparencies and/or others.

Eppenstein suggested generating a few this summer as examples. There was general agreement.

Report from Charles Stoll of Wiley: There is high priority (and high enthusiasm) for PSNS at Wiley. Wiley expected to have more input into text content and format but found PSNS had an eye on consumer needs, so they did not need to. However, in layout and design he feels they had a big input. In terms of marketing, the returns are not yet in, but advance orders look promising. The "travelers" are well prepared to do their difficult job.

There was a discussion of Damon-Wiley relations. It was reported that the growing pains are about over, and orders are now being filled promptly and accurately.

The matter of high school marketing arose. Strassenburg agreed to draft a statement concerning the position of the Advisory Board with respect to school sales, circulate it for comment by the Board, and then send it to Wiley.

Mr. Stoll reported on the management of the Special Fund. The sale of the book will generate funds for promotion of existing PSNS materials and possible future revisions.

Holden asked if there is a plan to revise the text to make a school edition which is different. Strassenburg replied that we as a body cannot undertake it. All we can do is encourage Wiley to arrange for revisions as needed.

Bassett reported on requests for translations. Some Japanese are interested in the possibility of a translation into Japanese. He described to them the appropriate procedure to request needed approvals from Wiley and NSF.

The meeting was adjourned at 4:30 p.m.

Respectfully submitted by

Elizabeth A. Wood

April 11, 1969

APPENDIX D-2

Policy Statement on Use of

PSNS in Secondary Schools

AMERICAN INSTITUTE OF PHYSICS
335 EAST 45 STREET, NEW YORK, NEW YORK 10017 • (212) 685-1940

OFFICE OF
EDUCATION AND MANPOWER
A. A. STRASSENBURG, *Director*

Reply to:
516-751-8300
STATE UNIVERSITY OF NEW YORK
STONY BROOK, NEW YORK 11790

June 3, 1969

Mr. Charles Stoll
John Wiley and Sons, Inc.
605 Third Avenue
New York, N.Y. 10016

Dear Mr. Stoll,

The Advisory Board for the Physical Science for Nonscience Students Project met recently and considered the possible use of PSNS materials in the high schools of this country. The Board members ultimately approved a position paper on this subject; a copy is enclosed.

We feel sure that John Wiley and Sons will be interested in this action. Please feel free to use the statement in any way that will help to promote appropriate experiments with PSNS materials in the high schools.

We look forward to continuing cooperation with you. Please keep us informed about the success or failure of "An Approach to Physical Science" as a high school text.

Sincerely yours,

A.A. Strassenburg

Enc.

AAS/hg

"AN APPROACH TO PHYSICAL SCIENCE" AS A SECONDARY SCHOOL COURSE

The staff of the Physical Science for Nonscience Students Project designed and developed materials for a course which would serve the needs of college students who plan to become elementary school teachers. The students are expected to participate in the careful observation of physical phenomena and to use simple apparatus to determine the relationships between measurable properties of matter. They are encouraged to develop concepts and models which help to relate their observations. Finally, students are asked to deduce from their models specific predictions which can then be tested by additional experiments. These activities are stressed because the staff believes they are the essence of the scientific method, and that observation, creative model-making, logical reasoning, and experimental inquiry are processes which should be emphasized in elementary school science courses.

The questions, experiments, and discussion in the PSNS text prescribe a variety of open-ended activities. They are designed so that students without unusual mathematical talent or previous experience with experimental science can participate successfully. The staff feels that this is important because elementary school teachers need confidence in their ability to seek answers to questions about science in a scientific manner; prospective teachers frequently lack this confidence when they enter college. The course designers also anticipate that students will enjoy the experiments and problems. This is important because negative attitudes toward science are efficiently transmitted from teacher to student in the classroom.

The content of the course -- selected from within the scope of physical science -- is interdisciplinary, because the staff believes that at elementary school levels it is more important to stress the general applicability of basic scientific concepts than the special techniques and language of any particular discipline. The length of the course, one academic year, was chosen as a compromise between the need of the neophyte investigator for an unhurried opportunity to look and think, and the heavy demands on education majors for professional preparation and for courses distributed over several different areas of knowledge.

Thus many decisions concerning course characteristics were made with the needs of prospective elementary school teachers in mind. It is clear, however, that many college students majoring in a variety of nonscience fields have experiences and needs not unlike those of typical elementary education majors. Many have suffered through a minimum of pre-college science courses without gaining understanding or appreciation of the ways scientists attack problems. They have tried to perform experiments and solve problems, but without pleasure or sense of purpose. They will study science as little as possible in college. They will have little use for the specific research techniques of any particular scientific discipline, but great need to employ systematic data-gathering and reasoning processes in their everyday lives. The staff and Advisory Board of the PSNS Project believe that such students would profit more from the PSNS course than from most science survey courses or from the more mathematically sophisticated courses designed for science majors.

Clearly the PSNS course was developed with the needs of nonscience college st lents in mind; the possibility of offering the course to high school students arose after the materials were developed. The members of the Advisory Board do agree that there is no obvious reason why the course should not be successful for some high school students. Undoubtedly, many students in high school have already developed negative attitudes toward science which PSNS may help to dispel. The involvement of PSNS students in systematic efforts to understand physical phenomena should be useful even for those students who eventually concentrate their efforts within a field of science. The degree of mathematical and experimental skill required of successful students is not above the level of many high school juniors and seniors.

The assignment of high school students to the PSNS course must be done intelligently. Inasmuch as the vocabulary and style of analysis in the text have been chosen to be attractive to students who have not yet been excited by scientific ideas, logical reasoning, and experimental procedures, it would seem prudent to counsel against the enrollment of students who are talented at mathematics or who have career goals in the physical sciences. Within this general guideline, the Advisory Board invites experiments with PSNS in secondary schools and hopes the results of such experiments will be reported.

6/3/69

APPENDIX E-1

Two PSNS Institute Reports

Director's Report

National Science Foundation

Summer Institute in the Natural Sciences

Rensselaer Polytechnic Institute

June 24 - August 16, 1968

A. A. Strassenburg

Co-Director

S. C. Bunce

Co-Director

THE PROGRAM

The program of the Institute combined laboratory experiments and discussion of the concepts and methodology of the PSNS course, "An Approach to Physical Science," supplementary activities shared by all participants, such as films, mathematics reviews, and guest lectures, and study of concepts in one field of science (physics or chemistry). The concepts were chosen by their pertinence to the development of concepts in the PSNS course and participants were individually assigned to the area in which they were least well prepared.

The daily schedule (except for a modification to accomodate films on Fridays) was as follows:

9:00 - 10:30 am:	PSNS Experimental work
10:30 - 11:00 am:	Coffee Break
11:00 - 12:00 am:	PSNS Discussion
12:00 - 1:30 pm:	Lunch
1:30 - 2:45 pm:	Group A: Chemistry Group B: Physics
2:45 - 3:00 pm:	Coffee Break
3:00 - pm:	Monday and Thursday: Films Tuesdays: Mathematics Review Wednesday and Friday: Guest Lecture or Library or open

These activites are discussed in more detail below.

A. Activities Shared by All Participants

1. PSNS Laboratory Experiments

Each morning was devoted to performing and discussing PSNS experiments. A schedule was established which called for completing one or two experiments each day and thus all sixty-odd experiments described in the text were performed by the participants during the summer.

Usually the participants had little difficulty collecting the data required between 9:00 a.m. and 10:30 a.m. Following a coffee break, the group assembled in a classroom near the lab and discussed the significance of the experiments. These discussions -- called pre-lab or post-lab discussions, depending on whether we were looking forward or backward -- were regarded by the participants and the staff as essential to the realization of Institute goals. It was during these sessions that we were able to examine the rationale for the organization of the subject matter and the philosophy behind the methods of presentation. All five instructors participated as discussion leaders; at no time were less than two present. The very open-ended and non-authoritarian style used by the instructors appeared to be the most surprising and controversial feature of the Institute program. There was evidence that many participants were won over by the promise of this technique for stimulating involvement and interest on the part of students.

2. Films

Two afternoons each week, starting at 3:00 p.m. and lasting one to one and a half hours, films were shown. These were selected to complement the PSNS laboratory experiments, the physics coursework, or the chemistry coursework. A large number of the films shown were made by either the PSSC or the CHEM Study Projects, though films from other sources were also used. During the summer, PSNS staff members were reviewing films for recommendation in the Teacher's Resource Book; therefore our knowledge of and access to relevant films were excellent. The films to be shown were listed well in advance so that participants could decide whether or not to attend. Occasionally non-Institute members of the campus community joined us at film showings.

Every Friday morning at 11:00 a.m., one of the Feynman Messanger Lectures, filmed for the BBC, was shown on the campus. We arranged our schedule so that our participants could attend, and a significant fraction did attend regularly.

3. Mathematics Review Sessions

Every Tuesday from 3:00 p.m. to 4:15 p.m., a review of some topic in mathematics was offered by Professor Strassenburg. The topics covered included vectors, the graphical meaning of calculus operations, statistics with application to error theory, exponentials and logarithms, complex numbers with applications to optical intensity patterns and A.C. electric circuit theory, and vector differential operators.

These sessions were very popular with the better students, and attendance at most sessions was large: approximately 90% of the participants for the easier topics down to perhaps 40% for the harder ones. The selection of topics -- after the first week -- was made in response to specific requests or by democratic choice from a number of alternatives suggested by the instructor or by students.

4. Guest Lectures

Four off-campus, invited guests gave one or two lectures or conducted regular class sessions during the eight-week program.

(a) Dr. Elizabeth Wood, retired Bell Laboratory crystallographer and Associate Director of the PSNS Project, conducted classes for the two days devoted to the chapters on "Crystals In and Out of the Laboratory" and the historical development of x-ray diffraction as a technique for determining crystal structure.

(b) Dr. Charles Price, chemistry from the University of Pennsylvania, gave two lectures: (1) "Polymers; How Properties are Related to Structure," and (2) "Evolution and Synthesis of Living Systems."

(c) Dr. Arthur Livermore, Deputy Director of Education of the American Association for the Advancement of Science, described to the group the AAAS elementary science curriculum project and text and laboratory

materials known under the name "Science, A Process Approach." He indicated how PSNS could serve as a suitable physical science course to prepare teachers of these materials.

(d) Dr. Donald Holcomb, physicist at Cornell University, spoke twice about an innovative course in physics which he teachers to non-science majors at his institution. While the topics he covers are different from those in the PSNS course, his style of teaching, like ours, is directed toward securing student involvement.

Professor L. V. Parsegian of RPI was also invited to describe his course development program: "An Integrated Approach to Science."

B. The Physics Course

The physics class, consisting of 20 teachers whose primary competence lay in chemistry, met every afternoon from 1:30 p.m. to 2:45 p.m. Professor Strassenburg and Professor Whitcomb shared the duties of instructor. Topics were selected from an introductory college physics text, Classical Physics by Weidner and Sells, on the basis of their close relationship to the PSNS course. The approach used during the first six weeks was strongly analytical, in order to illustrate convincingly the power of physical theory and mathematics in the organization and understanding of physical phenomena. Problems were assigned, collected, and checked in order to monitor the progress of the class.

The topics covered during this phase included kinematics, dynamics, conservation of energy, electrostatics, wave motion, interference and diffraction, and thermodynamics. The final two weeks were devoted to lectures on atomic and nuclear models and quantum physics. For this final phase, students were supplied with reading lists with references to half a dozen books on the topic for each day, and several copies of each book were made available.

Though no credit was given for this course, it was roughly equivalent to one semester of an introductory physics course requiring calculus as a co-requisite. Some participants undoubtedly mastered an appreciable amount of quantitative physics; others profited only from the qualitative aspects of the presentation. No exams were given, so we have no way to measure class achievement objectively, but we believe the course served the needs of future teachers of PSNS.

C. The Chemistry Course

The chemistry class, meeting at the same time as the physics class, consisted of the other half of the participants, those whose backgrounds were not as strong in chemistry as in physics. The text Bassett, Bunce, Clark, Carter, and Hollinger, Principles of Chemistry, used as a primary reference, was supplemented by a collection of paperbacks. Topics discussed in some depth included atomic structure, ionic solids and crystal structure, covalent bonding, structure of more complex covalent carbon compounds, covalent solids, metallic solids, Van der Waals' bonding in solids, the liquid state, gases, chemical thermodynamics, solutions and phase equilibrium, kinetics of chemical reactions, electrochemistry, and mechanisms of reactions of ionic

and covalent compounds.

Assignments were given in advance and included questions and problems, which were generally worked on with care by participants, corrected by the staff and by graduate assistants, and returned to the participants. Active participation in assigned work and in class discussion was the norm, although a few participants were unable to keep up with the work. The level of discussion was somewhat more advanced than that of a typical present-day general chemistry course, and the topics included at least those which would be found in one semester of such a course.

The chemistry instruction was shared by Professors Bunce, Campbell, and Hollinger. Often for discussions, two of the three were present and the informal discussions proved very stimulating. The progress on assigned problems, and the class discussions indicated that this part of the program was of considerable value to most of the participants, and that it was particularly relevant to their teaching the PSNS course.

THE PARTICIPANTS

A. Selection

A brochure describing the program was mailed to all who learned of the program from the NSF national brochure, and also to all college and junior college science school or division heads. The Office of Continuing Studies at Rensselaer received 112 applications; all of these were reviewed carefully by the Directors and a composite judgement was made of the ability of the applicant to benefit from participation.

There were 51 first offers made; rejection of 22 of these led us to make offers to approximately 28 of a list of 36 ranked alternates. The group of 40 participants so chosen was augmented by one foreign participant who was invited following a suggestion of the National Science Foundation, and by two local participants, ineligible for stipends because they were secondary school teachers. There were no withdrawals after the program began.

Half of the participants (20) were from four-year colleges and half (20) were teaching at two-year colleges and junior colleges. One had a Ph.D. degree, most had M.S. degrees, about equally distributed in science and in science education. They came from seventeen states and from Argentina, and their institutions included private liberal arts colleges, large public universities, large public junior colleges, and state colleges which are primarily teacher-preparing institutions.

B. Participant Facilities and Recreation

Participants were housed and had their meals in Rensselaer dormitories or,

in some cases, in private apartments or houses which they leased. These arrangements seemed quite satisfactory. Association with those participating in the PSNS writing program, and also with college and secondary school science teachers who were participants in other NSF summer programs at Rensselaer was helpful.

One picnic was arranged by all NSF summer program participants and some other informal social activities were included. A visit to some of the research facilities related to structural studies in the new Materials Research Center concluded the program.

EARLHAM COLLEGE
SUMMER INSTITUTE FOR COLLEGE TEACHERS
OF PHYSICAL SCIENCE
1970

From June 21 to August 14 thirty one college physical science teachers were on the Earlham campus attending a summer institute supported by the National Science Foundation. The Institute was designed to develop the participant's ability to present physical science to non-science students. About two thirds of the participants are on the staff of a junior college and one third are from four year institutions. Half received their major training in chemistry and half in physics. Three participants came from California, two from Florida and one from Washington. There were none attending from Indiana or Ohio.

Mornings were spent performing the experiments of the "PSNS - An Approach to Physical Science" course. The discussions following the experiments focussed on: interpretation of the results, relation of the experiment to the general theme, and methods of generating interest and involvement. The PSNS course used during the Institute has been available to Earlham students for five years. The co-directors of the Institute, Dr. Henry Hollinger of the Department of Chemistry, Rensselaer Polytechnic Institute, and Dr. Stuart Whitcomb of the Earlham Department of Physics, were both on the staff which developed the PSNS material. They took turns conducting the morning sessions.

The first part of the afternoon was spent in giving additional chemistry training to participants whose major experience has been in physics and physics training to participants experienced in chemistry. The rest of the afternoon was spent on review of mathematics, viewing films or in attending special programs.

During the eight weeks of the Institute five invited speakers spent from a few hours to two days talking with the participants. These guests were:

Dr. Elizabeth Wood, formerly Chairman of the PSNS Advisory Board, member of the Commission on College Physics;

Dr. Charles Overberger, Chairman of the Department of Chemistry, University of Michigan, and former President of the American Chemical Society;

Dr. Arnold A. Strassenburg, Chairman of the PSNS Advisory Board, Director of Education and Manpower, American Institute of Physics;

Dr. Bernard McGinnis, Chemist, Indiana Pollution Control Board;

Dr. Lawrence Strong, Chairman, ACS Division of Undergraduate Education, Earlham Department of Chemistry.

The Institute proved to be a very valuable experience for most of the participants and for the Directors. The thirty one participants were a very congenial, friendly and willing group. They were very easy to work with and their presence on the campus improved the general morale of all summer programs.

The operation of this program was made very easy by the fine cooperation of Wanda Harvey and Kathy Smith of the Conference Office, the SAGA Food Service, Lois McMahon and Bob Godsey in the Housing Office, the student assistants Nobuyoshi Fukada and Alec Farley and the Department of Physics secretary, Sandy Sergent.

Appendix E-2

Three Typical Workshop Reports

AMERICAN INSTITUTE OF PHYSICS

335 EAST 45 STREET, NEW YORK, NEW YORK 10017 • (212) 685-1940

OFFICE OF
EDUCATION AND MANPOWER
A. A. STRASSENBURG, *Director*

Reply to:
STATE UNIVERSITY OF NEW YORK
STONY BROOK, NEW YORK 11790
516 751-8300

April 1, 1970

Mrs. Elizabeth A. Wood
37 Pine Court
New Providence, New Jersey 07974

Dear Betty:

I would like to report to you on the PSNS workshop that I conducted at the State University of New York College at Buffalo on March 21, 1970. I arrived at the Buffalo airport on Friday evening and was met by Joe Burns, the local Wiley representative. He took me to a motel near the Buffalo campus which had been reserved for me by John Barnett, the physical science teacher at the college. Despite the fact that his wife had had a baby by Caesarean section on Friday, John Barnett picked me up early on Saturday morning and took me to the college. All of the apparatus I had ordered had arrived in time and was conveniently packaged and ready for use. The visitors were not scheduled to arrive until 10:00 a.m. which gave me adequate time for preparing numerous experiments and demonstrations which were part of my workshop plan.

Approximately 70 participants arrived at about 10:00 a.m. During the morning I asked them to perform experiments with crystals: salol experiment, cleaving of crystals and making crystal models with styrofoam balls and toothpicks. I also conducted several demonstrations carrying out the general theme of investigations into crystal structure as contained in the PSNS text. There were numerous questions and comments about the teaching style and discovery philosophy on which the PSNS course is based.

After a good lunch provided at the campus cafeteria and paid for by Wiley, we returned to the science building, and split into two groups. I had one group perform the measurement of the wavelength of light viewed through two slits while I discussed with the others various devices including experiments, demonstrations, and films by which the course attempts to familiarize the student with the concepts of wave motion and interference. Midway through the afternoon we reversed the two groups and repeated the experiments and demonstrations.

I thought everything went reasonably well despite the fact that I planned too much to do. There were many questions and much discussion from the group which reflected some reluctance to accept our progressive teaching styles but also indicated considerable interest. A number of people were ready to be persuaded

and will undoubtedly adopt the course. A number of others will take more persuading but at least they will give some consideration to our methods. I feel that in general the workshop served the purpose for which it was intended.

Let me know if I can help with your workshop program.

Sincerely yours,

AAS:kv

A. A. Strassenburg

cc: Gene Davenport
Lewis Bassett

EARLHAM COLLEGE
RICHMOND, INDIANA 47374

28 April 1970

Dr. Elizabeth A. Wood
37 Pine Court
New Providence, New Jersey 07974

Dear Betty:

Thanks for your letter of April 21, 1970. I will be glad to take care of the PSNS Workshop at Southern Illinois University at Carbondale on May 23. I called Dr. Sullivan at SIU this afternoon and made the preliminary arrangements. He expects to have between 30 and 50 people there from the southern part of Illinois and the southeastern area of Missouri. He plans to start the workshop at nine, continue until twelve and then from one until two-thirty. I will propose the following schedule:

9:00 Introduction (45 minutes)
The Philosophy and Approach of PSNS
The PSNS text, Resource Book and Supplement

9:45 Experiments and Discussion (2 hours, 15 minutes)
The participants will follow the thread of the text by performing the following experiments and discussing the intervening material.
Exp. 1-1 Salol Experiment
3-2 Colored Objects
4-1 Young's Double Slit Experiment
4-D Demonstration of the Ripple Tank Experiment
5-3 Cleaving Crystals
12-2 A Simple Electric Circuit
12-4 A Mechanical Analog to Conduction in Solids

12:00 Lunch

1:00 Continuation of Morning Session (30 minutes)
Exp. 17-3 Physical Properties of Sulfur
17-4 A Model of Sulfur

1:30 Discussion and Question Period (60 minutes)
1. Scheduling the Course
2. Laboratories and Equipment
3. Examinations

2:30 Adjournment

I think that this will keep everyone usefully busy.

I am writing to Gene Davenport giving him a list of the equipment I will need with the suggestion that he send it here. I will take some of our PSNS materials from here, ripple tank, Mechanical analog, etc. I plan to drive. Upon completion of the workshop I'll send you a report and a bill for my services to Lew Bassett.

Some time ago Gene Davenport gave my name to Richard C. McLeod of the Science & Math Teaching Center at Michigan State. He is Program Chairman for the National Science Teachers Association, Great Lakes Regional Conference to be held on October 8, 9, 10 at Grand Rapids, Michigan. As a result I have agreed to do a workshop on October 9 from 3:30-5:00. I hope that PSNS will be able to pay my expenses even though the arrangements were not made in the usual way. Will you please let me know so that if PSNS cannot support this I am sure that Wiley will since the arrangements were made through them.

The summer institute seems to be shaping up well. We had 120+ applicants and now after only 20 phone call we have committtments from 30 participants. Henry and I have worked out a schedule and we plan to do Chapter 5 on June 30 and Chapter 6 on July 1, would it be possible for you to plan to come to Richmond for one or both of these days. If some other day that week would be more convenient we can make the necessary adjustments.

Best wishes,

Stuart

Stuart E. Whitcomb
Professor and Chairman
Department of Physics

SEW:ls

SOUTH COUNTY JOINT JUNIOR COLLEGE DISTRICT

CHABOT COLLEGE

25555 Hesperian Boulevard · Hayward, California · Telephone 782-3000

division of Science and Mathematics

May 4, 1970

Dr. Elizabeth Wood
37 Pine Court
New Providence, N. J. 07974

Dear Betty:

After two successful PSNS workshops I can now write you some of the details.

On March 14 I directed a workshop at South Texas Junior College in Houston. It was attended by more than 20 teachers from nearby junior colleges, four-year colleges and universities. During the day we not only discussed PSNS in a style that could only be described as the relaxed atmosphere of the South's hospitality, but we performed the following experiments:

1. Experiment 1-1 Salol
2. 1-3 Potassium permanganate
3. 4-1, 2 Young's double slit experiment
4. 4-3 Using the wavelength of light determined in 4-2 we determined the grating spacing in the mesh.
5. 5-3 Cleaving crystals
6. 13-1 Collision probabilities
7. 14-2 Migration of ions

This selection was made to show the diversity of the PSNS course, and yet reveal the main stem. There was something for the physicist and something for the chemist.

South Texas Junior College, although it is located in the old Merchants and Marketing building in downtown Houston, had first-rate lab facilities for the PSNS Workshop. There were regular height tables and chairs (as against lab tables and stools). Mr. Frank Price, chairman of the science department, cooperated in every way.

At the conclusion of this workshop, nearly every participant came forward, shook my hand and thanked me for going all the way to South Texas to tell them about PSNS. They each indicated that they were impressed with the purposes of the course and with the way it was being carried out. I feel sure that PSNS made some good friends on that day.

On April 25 I conducted a similar workshop at Portland State University in Portland, Oregon. There were 40 in attendance at this workshop, representing some 27 institutions. There were representatives from junior colleges, state colleges, private colleges, and universities in both Washington and Oregon. I again conducted the same experiments and with success.

The southern hospitality was replaced by the friendliness of the Pacific Northwest - for the most part. There were some pompous professors in attendance who looked upon all this cleaving, scratching slits, and marble rolling as so much tomfoolery. They did watch, however, and even returned for the afternoon session!

The facilities at Portland State University were good, but having 40 participants meant that we saw more rooms and labs at Portland State than I saw in Texas. This made for some inconveniences, but Dr. Bruce Kaiser did a splendid job of taking care of local arrangements. He, as you know, is in the general science department there.

Again many of the participants personally expressed their thanks upon the completion of the workshop. I'm sure that we made some more good friends.

Although not a workshop, and although not arranged through the good offices of PSNS-Wiley, I gave a talk on April 18 to a meeting of the California Association of Chemistry Teachers. This was an honor and I told them so. But I also tactfully and with good humor scolded them a little for their lack of interest in teaching physical science and their lack of interest in future elementary school teachers.

That I hit home was made clear by both their warm applause and their comments and questions at the end. Comments had to be cut short (after 20 minutes) for the next speaker. The meeting took place at West Valley Community College in Saratoga, California, just west of San Jose.

I did enjoy conducting these workshops, Betty, and talking about PSNS to the chemists. It is a great course; I like it even more after having taught it.

My very kind regards to you and to Sandy.

Cordially,

Stuart J. Inglis

APPENDIX E-3

Four Newsletters and a Special Communication

THE PSNS PROJECT NEWSLETTER NO. 1

December, 1965

Background and Philosophy

During 1963 and 1964 the Commission on College Physics and the Advisory Council for College Chemistry sponsored a series of conferences to encourage the birth of a project to design a new course in physical science for nonscience majors. As an outgrowth of these conferences the PSNS Project was born in April 1965 at Rensselaer Polytechnic Institute, Troy, New York, under a grant from the National Science Foundation, with Professor Lewis G. Bassett of the Chemistry Department of RPI as Director, Dr. Elizabeth A. Wood of the Physical Research Department of Bell Telephone Laboratories as Associate Director and Chairman of the Advisory Board and Professor Robert L. Sells of the Physics Department of the State University of New York College at Geneseo as Associate Director.

Other members of the 1965 staff of the project were as follows:

John J. Banewicz
Department of Chemistry
Southern Methodist University
Dallas, Texas

Stanley C. Bunce
Department of Chemistry
Rensselaer Polytechnic Institute
Troy, New York

Wilfred E. Campbell
Department of Engineering
Rensselaer Polytechnic Institute
Troy, New York

Earl L. Carlyon
Department of Physics
State University of New York at Geneseo
Geneseo, New York

T. Handley Diehl
Department of Science Education
Miami University
Oxford, Ohio

Walter E. Eppenstein
Department of Physics
Harvard University
Cambridge, Massachusetts

J. Lawrence Katz
Department of Physics
Rensselaer Polytechnic Institute
Troy, New York

Harry M. Landis
Department of Physics
Wheaton College
Norton, Massachusetts

Samuel H. Lee
Department of Chemistry
Texas Technological University
Lubbock, Texas

Harry F. Meiners
Department of Physics
Rensselaer Polytechnic Institute
Troy, New York

Earl J. Montague
Department of Science Education
Ball State University
Muncie, Indiana

Lyman V. Racster
Department of Chemistry
Rensselaer Polytechnic Institute
Troy, New York

Albert J. Read
Department of Physics
State University of New York at Oneonta
Oneonta, New York

Frank J. Reynolds
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West Chester State College
West Chester, Pennsylvania

Robert Resnick
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Troy, New York

Russell K. Rickert
Department of Physics
West Chester State College
West Chester, Pennsylvania

Richard S. Sakurai
Department of Physics
Western College for Women
Oxford, Ohio

Lois Smith
Department of Chemistry
Russell Sage College
Troy, New York

Paul Westmeyer
Department of Chemistry
University of Texas
Austin, Texas

Elnora Wright
Department of Education
Montana State College
Bozeman, Montana

The PSNS Advisory Board is constituted as follows:

Lewis G. Bassett, Rensselaer Polytechnic Institute

Alan N. Holden, Bell Telephone Laboratories

Frank R. Kille, N.Y. State Department of Education

Arthur H. Livermore, AAAS

Charles C. Price, University of Pennsylvania

Robert Resnick, Rensselaer Polytechnic Institute

Robert L. Sells, State University of N.Y. College at Geneseo

Elizabeth A. Wood, Bell Telephone Laboratories, Chairman

The purpose of the Project is to develop a new type of course in physical science to be given in liberal arts colleges and teacher training institutions to nonscience majors. The primary target is the prospective elementary-school teacher, but the course may prove suitable for other categories of students.

The prospective elementary-school teacher will have a strong influence on the minds of our future citizens during their most impressionable years. Most prospective elementary-school teachers are not science oriented. Many of them have a sense of anxiety and personal inadequacy in science. Since this distress may well be transmitted to their students, we feel that it is a task of importance to provide the prospective elementary-school teachers with a sense of being at home with science, the confidence to do things with their own hands, and an appreciation that curiosity and a child-like desire to experiment are closer to the spirit of scientific research than memorizing facts from an encyclopedia.

To this end the student of physical science must have time to investigate and must be enticed into wanting to investigate. The research scientist commonly gets his impetus for investigation from coming upon something puzzling and he eagerly goes about finding out what he needs to know to solve the puzzle. Those designing the PSNS course hope to capture some of this impetus by proceeding from

through the need to know. To do this takes time. To gain time the subject matter must be drastically limited.

We have chosen to focus attention on the nature of solid matter and how we find out about it. This includes some excursions into the investigation of liquids and gases because of the light such investigation sheds on the nature of solids. This area was chosen not only because the material is so inextricably involved with both physics and chemistry as conventionally defined, but because it seemed to us that many simple experiments could be performed by the student in such a course.

Experiments

Experimental experience is central to physical science. It should be central to any course in physical science. Since some colleges do not have laboratories available to these students the PSNS staff has designed a number of "take-home" experiments which require nothing more than a table top and a source of running water in addition to some simple inexpensive equipment supplied in kit form. Descriptions of these experiments are an integral part of the text.

Another type of non-laboratory experiment is the chair-arm experiment, an experiment designed to be performed by all students in the class simultaneously on the arms of the chairs in the lecture room during the lecture period.

"Regular Laboratory"

In some colleges where a regular laboratory period is part of the physical science course, the instructor may wish to have

the students do the "take-home" experiments in the laboratory room, but the usual time restrictions should not be imposed.

Some "exercises" in existing laboratory manuals are appropriate for use with this course and can be recommended. It is likely that additional "regular laboratory" experiments will be generated by the PSNS staff in the future for the benefit of those colleges where regularly equipped laboratories are available for the students of this course.

Form of the Course

One of the most important ingredients in the success of a course is the enthusiasm of the instructor for teaching it. He will probably have more enthusiasm for it if he has had some share of responsibility in creating it. For this reason, the form of the PSNS course consists of a Main Stem of subject matter with associated experiments, reading, etc. and "Optional Packages" of subject matter, experiments, etc. to be intercalated with the Main Stem material at the option of the instructor.

The Main Stem material does not assume knowledge of any of the Optional Package material. The Optional Package material assumes only knowledge of the Main Stem material.

Pace

The student must have time to observe, to wonder, to generate hypotheses, to experiment and to read material other than the text if he is going to get the feel of participation in scientific investigation which we hope he will get from this course. The instructor must never feel that he has to say "We haven't time to go into that because we have to cover the material of the course". No course covers

the whole of physical sience. The selection of material covered is bound to be somewhat arbitrary. The instructor who encourages the student to investigate further something which puzzles him even though this may mean omitting other parts of the course is acting in the spirit of the originators of PSNS.

Even when the pace is leisurely enough to allow such investigation, there should be time to include some of the Optional Package material. For this reason the Main Stem material must be less than that appropriate for a one-year course.

Progress to Date

The PSNS staff listed in the early part of this Newsletter met at Rensselaer Polytechnic Institute throughout the summer of 1965 to produce the Main Stem material with associated non-laboratory experiments. Optional Packages, the Instructor's Sourcebook, problems and examination questions, as well as regular laboratory experiments, were considered to have lower priority and will be produced later. A number of existing films, largely those produced by Chem Study and PSSC, were critically reviewed by the staff and some were recommended for use with PSNS. In a number of cases, the staff felt that parts of the film would be appropriate whereas other parts would not, but there was not time to make the necessary arrangements for such editing before the 1965-1966 trial of the PSNS material.

Annotated Table of Contents

In the following table, the chapter titles are as they appear in the text, but the notes are intended for your information. They are not the section headings used in the text.

AN APPROACH TO PHYSICAL SCIENCE

Volume 1.

Chapter 1. YOU AND PHYSICAL SCIENCE
Introduction. Observation. Questions. Experiments

Chapter 2. WAYS AND MEANS
Measurement. Time. Space. Temperature. Weight.

Chapter 3. A LOOK AT LIGHT
Color. Wave model of light.

Volume 2.

Chapter 4. INTERFERENCE AND DIFFRACTION
Resolution. Single and double slits. Two- and three-dimensional gratings.

Chapter 5. CRYSTALS IN AND OUT OF THE LABORATORY
Growth of crystals from melts and solution. Minerals. Periodicity evidence.

Chapter 6. WHAT HAPPENED IN 1912
The story of the Von Laue experiment. (This brings together Threads developed in Chapters 4 and 5).

Volume 3.

Chapter 7. MATTER IN MOTION
F=ma. Work. Energy.

Chapter 8. MOLECULES IN MOTION
Gases. Molecules. Kinetic theory.

Chapter 9. SOLID MATTER: A CLOSER LOOK AT DIFFERENCES
Properties of matter. Melting points. Boiling points.

Chapter 10. FORCES INSIDE MATTER
Search for force that might be responsible for the attraction between particles of matter (and also the repulsion that fixes distances). Gravitational force explored and discarded. Electrostatic force explored and accepted as preferred hypothesis.

Chapter 11. ELECTRIC CHARGES IN MOTION
Potential. Current. Units defined.

Volume 4.

Chapter 12. MODELS OF ATOMS
Historic development. Electronic configuration. Energy levels. Chemical symbols.

Chapter 13. IONS AND OTHER THINGS
Electrolysis of melts and solutions. Simple and complex ions. Chemical formulas and equations.

Chapter 14. CRYSTAL STRUCTURE OF AN IONIC SOLID

Volume 5.

Chapter 15. MOLECULES

Chapter 16. BONDING IN A COVALENT SOLID

Chapter 17. CHEMICAL REACTIONS

Chapter 18. SO WHAT
What have we learned about the nature of scientific investigation? What have we discovered about the world around us? Through what avenues will we continue to broaden and deepen this knowledge?

Samples of the Text

The following excerpt from the text has been chosen to show the level and style of some of the material. The level increases in sophistication and difficulty as the course progresses.

From Chapter 1: Section 1-4

1.4 Answerable and Unanswerable Questions

In the history of science, some of the most important contributions have consisted of asking the right questions, questions which laid bare the heart of a problem and which were answerable by a specific experiment or sequence of experiments. It is much harder to ask this kind of question than it is to ask a very complicated question which involves a broad body of knowledge in its answer. Childred often ask very complicated questions, answerable fully only by a highly specialized expert. "How do you make an atomic bomb?" "Why is grass green?" "What makes water so wet?"

Some questions are a matter of semantics, involving the particular meaning that you ascribe to a word in the question, "What do you mean by wet?" If your answer is "behaving like water," then the question becomes, "Why does water behave like water?" and the obvious answer is "Because that's what it is." If, however, you mean by wet the ability to spread out over a surface and make close contact with its every hump and hollow, then the question is a deeper one. "What is it, in the chemical and physical nature of water, that gives it this surface-covering ability, unlike mercury, for instance?"

A song that was popular some years ago contained the questions. "How deep is the ocean? How high is the sky?" These are two very different kinds of questions. The depth of the water in the ocean varies from zero at the shore to some maximum depth which has been measured and recorded by oceangraphers; we could look this up in a book on oceanography. To answer the second question, we need to ask the questioner what he means by the word sky. If he thinks of it as a flat lid on a flat earth like the ceiling of a room, then we have a lot of educating to do. Or perhaps he means, "How far away are the stars?" and must learn that the nearest one is so near that light from it can reach us in 4 years, but that most of them are much farther away. Or perhaps he means "How deep is the Earth's atmosphere?" in which case we have to tell him that there is less and less air as you go up from the surface of the earth, and we have to decide how little air we will accept as still constituting some air. This may lead him to ask, as scientists have in the past, "How can air get to be less and less? If there is less air, is it in separate bits or is it spread out thin, and what do you mean by thin air? What thins it?"

These are difficult questions. When scientists are confronted by difficult questions, they frequently resort to making simple models in their imagination and the model they have made to answer these questions about thin air and other gases will be one of the subjects of this course.

Cooperation with ESI

The staff of Education Services, Inc. has been most cooperative in making available to PSNS the fruits of their labors. Anyone who sees the PSNS text will recognize that such things as the ripple-tank photographs and the peg-board support for chemical experiments have been taken directly from ESI projects. We wish to take this opportunity to express our gratitude for their very helpful cooperation.

Current Trials

During the academic year 1965-66 the PSNS materials that are available are being tried out in the following colleges:

Ball State University, Muncie, Indiana
Miami University, Oxford, Ohio
Montana State College, Bozeman, Montana
State University of New York College at Geneseo, N.Y.
Webster College, Webster Groves, Missouri
West Chester State College, West Chester, Pennsylvania
Western College for Women, Oxford, Ohio

The text is given to the students in spiral-bound booklets each of which comprises a few chapters. The materials required for the experiments are shipped to the instructors in the amounts needed.

The Main Stem text was not completed by the end of the summer of 1965, though first drafts of all chapters had been written and duplicated for distribution to all members of the staff. The work of revision of the first drafts and preparation of the printed booklets has been carried on by six members of the staff, including the director and associate directors, during the academic year.

Future Plans

During the summer of 1966 some of the Main Stem material will be revised in the light of the current trials and the staff will proceed with the production of the additional materials originally planned.

During the academic year 1966-67 it is anticipated that most, perhaps all, of the colleges now trying the course will repeat it and that a few more colleges will be added.

The following conditions will apply to the acceptance of additional colleges for trial.

1. The course, including the experiments which are an integral part of it, must extend over the full academic year.
2. The instructor must agree to come to Rensselaer Polytechnic Institute at Troy, New York for a two-week briefing session, August 23-September 3, 1966. His traveling and subsistence expenses will be paid by the Project but he will receive no stipend from the Project.
3. The cost of all equipment for performing experiments will be borne by the Project.
4. The Project will not bear the full cost of the text booklets, but may be able to bear part of the cost.

Those interested in trying the course during the academic year 1966-67 are invited to write to Dr. Elizabeth Wood, Bell Telephone Laboratories, Murray Hill, N.J. Since it is desirable that the colleges trying the course be varied in type so that we may discover what groups the course serves best, you are urged to describe as fully as possible the nature of your college, the place the course

would occupy in the curriculum and the type of student who would be taking the course.

If you would like to receive subsequent issues of the PSNS Project Newsletter, please give your name and address on the blank below and mail it to Professor L.G. Bassett, Rensselaer Polytechnic Institute, Troy, N.Y., 12181, or address a letter to Professor Bassett. Those who received this letter through the mail will automatically receive subsequent newsletters.

Professor L.G. Bassett
Walker Laboratory
Rensselaer Polytechnic Institute
Troy, New York 12181

Dear Professor Bassett:

Please send me THE PSNS PROJECT NEWSLETTERS as indicated below

Name: ______________________

Address: ______________________

____

____

___ Newsletter No. 1

___ Subsequent Newsletters

The PSNS Project Newsletter No. 2
November 1966

The Physical Science for Nonscience Students Project located at Rensselaer Polytechnic Institute, Troy, New York, is now a year and a half old. The National Science Foundation has just awarded an extension to the grant to continue the project for another two years until the fall of 1968 when its termination is planned by its directors. For this two-year period its administrative staff will be as follows:

Director: Lewis G. Bassett; Professor of Chemistry, R.P.I.

Associate Director and Chairman of the Advisory Board: Arnold A. Strassenburg; Director of Education and Manpower, American Institute of Physics; Professor of Physics, State University of New York at Stony Brook

Associate Director: Robert L. Sells; Chairman of the Department of Physics, State University College at Geneseo, New York

Associate Director: Elizabeth A. Wood; Research Physicist, Bell Telephone Laboratories, Murray Hill, New Jersey

These, with the following additional members, will constitute the Advisory Board of the Project.

Donald F. Holcomb; Professor of Physics, Cornell University

Alan Holden; Research Chemist, Bell Telephone Laboratories

Frank R. Kille; Director of the Office of Science and Technology of the New York State Education Department

Arthur H. Livermore; Deputy Director of Education for the AAAS

Charles C. Price; Chairman of the Department of Chemistry, University of Pennsylvania

Robert Resnick; Professor of Physics, R.P.I.

James Werntz; Associate Professor of Physics and Director of Minnemast Project, University of Minnesota

The first Newsletter, issued in December 1965, described the background and philosophy of the PSNS Project and the form and content of the

course, giving a sample of the text. Copies of that Newsletter are available, on request, from the Director.

It is the purpose of this Newsletter to report project activities since December 1965, and to discuss future plans.

Results of 1965-66 Trials

During the academic year 1965-66 the PSNS materials were used in the following institutions:

Ball State University, Muncie, Indiana
Earlham College, Richmond, Indiana
Miami University, Oxford, Ohio
Montana State College, Bozeman, Montana
State University of New York College at Geneseo
Webster College, Webster Groves, Missouri
West Chester State College, West Chester, Pennsylvania
Western College for Women, Oxford, Ohio

Nearly all of these were enthusiastic about their experience with PSNS and are teaching it again this year. One instructor described the difference between PSNS and the physical science course he had previously taught as a difference in the sense of participation that his students felt.

> Since I am from a small school, I get many opportunities to talk to my former students. Whenever we talk about scientific things, the typical kind of phrase which my former standard physical science students use is " those things <u>you</u> <u>showed</u> us". A typical kind of phrase used by my former <u>PSNS</u> students is " those things <u>we</u> <u>did</u>". I think the difference between those two phrases is all the difference in the world. The differences are evident between the words <u>you</u> and <u>we</u>, and between <u>showed</u> and <u>did</u>.

Figure 1 shows some experimenters acquiring this sense of participation. They are growing salol crystals on a glass slide, right in the lecture room. This is a " chair-arm experiment" that is performed on

Figure 1

the first day of the course, to convince the students that the course will be centered in experiment and that science is a do-it-yourself thing in which they can participate. We hope it will encourage them to raise questions about the formation of a solid with a beautifully regular shape out of a formless liquid,and about the role played by heat, the nature of melting and crystallization.

One student complaint was frequently reported by the teachers in the early part of the course: since the material was interesting and seemed to require mostly common sense, it was not really science because science was, they were sure, dull and incomprehensible. Robert Karplus has suggested that we need " a bitter-coated sugar pill" for such students.

Although we have sent information out only on request and given talks about PSNS only when invited, we are finding that the interest in the course is very widespread. This interest originates in the feeling on the part of many college teachers that they are not offering a suitable course in physical science for nonscience students. An excerpt from a typical letter, dated 11 March 1966, follows:

> At this college I teach the physical science course for non-science and elementary education concentrators. For some years I have been troubled by the non-scientific orientation of many of those preparing to teach in the elementary school. At times this amounts to an apathy and even sometimes to a distinct antipathy towards science. I share your feeling that these people especially should learn to feel at home with the fundamental concepts of science. By the proper kind of course they could probably be motivated to undertake simple scientific investigation and perhaps to catch some of the fascination of research which they could then transmit to their pupils.
>
> The new PSNS course appeals to me so much that I should like to learn more about it and to try it next year. Toward this end I am enclosing a summary description of our college, its physics department, the physical science course, and the proposed place which the new course would have in the curriculum. We would be gratified to be selected as one of the colleges to help pilot this course.

F-om the same teacher came the following letter, dated 23 September 1966.

> At last I have begun teaching the PSNS course. I had my first classes yesterday and my first lab today.
>
> Their initial response to the PSNS Physical Science was very encouraging. I hope I can manage to keep them enthusiastic. Thank you so much for inviting us to help pilot this course. The briefing session at R.P.I. was very helpful. I found it extremely stimulating...........

Briefing Session for PSNS Teachers

The briefing session referred to was under the direction of Professor Arnold A. Strassenburg of the State University of New York at Stony Brook. His report of this session follows.

x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x

During the last two weeks of August 1966, teachers of physical science courses from institutions across the nation gathered at Rensselaer Polytechnic Institute to familiarize themselves with the written materials, the experiments, and the philosophy of the PSNS Course. These teachers are now using the second edition of the PSNS text — which has more questions and problems than the first version as well as revised experiments — and the first of several supplementary chapters most of which are still under preparation. The group will provide feedback which will lead to another revision of the materials, and they will also help the PSNS staff assemble a Resource Book to help additional teachers to use the materials in future years.

As group leader for this briefing session, I am delighted to report that the interaction seemed to be profitable for all concerned. This happy result flies in the face of all reasonable expectation. The participants were a wildly inhomogeneous lot, and I was personally bewildered in attempting to plan activities which would take advantage of the diverse experiences and valuable critical faculties of the group while still allowing adequate time to explore the peculiarities of our apparatus and the importance of certain teaching techniques.

As the list below will reveal, some of these trial teachers are employed by large universities, some by small two-year colleges. State-supported institutions frequently teach physical science courses for prospective elementary school teachers, but private colleges are also well represented among those that are looking for something new in the way of courses for nonscience majors; apparently both groups believe PSNS may meet

their needs. Some of these teachers were trained primarily as physicists, some as chemists, and some much more broadly as science educators.

The courses they teach differ almost as much as the teachers. Some are required in a teacher-preparation-curriculum, some are elected by a variety of liberal arts majors. Some courses award four semester hours of credit, others only three. Trials have been conducted with classes as large as 880 students and as small as fifteen. The only common requirements are that each course is taught for a full academic year, and each makes some provision for laboratory work and demonstrations. These were ironclad requirements among the 1966 criteria for selection of tral institutions.

The following were included among the scheduled events for the briefing session:

(1) The participants and staff members performed selected PSNS experiments. Later we held post-lab discussions to compare experiences and discover how to extract the most from each lesson.

(2) Specified sections of the text were discussed in detail. The participants played with devastating effect (on me) the role of curious but uninformed students. These sessions had two very beneficial effects. They caused us again and again to reexamine the very important but difficult technique of leading students to discover truth about nature and ways of drawing general conclusions from observations without telling them too much in an authoritative way. In addition, the wide practical experience of these teachers enabled them to indicate to us numerous places where either the students or teachers would need additional help.

(3) Examination questions were constructed and dissected without mercy. Every one of us profited from hearing how ambiguous our best efforts seemed, even to a fellow teacher who knows the subject.

(4) Some problem sets were solved and discussed in detail. Again it was enlightening to see how much each teacher could contribute to the lessons to be learned from a simple, thought-provoking question.

(5) Films and supplementary reading materials were reviewed, and apparatus designed to assist in presenting certain concepts was demonstrated.

The result of all this activity is that the course authors will now have their hands full making many improvements suggested by the alert and critical participants, and the teachers will be busy for the coming year in their efforts to put into practice the many valuable suggestions made by colleagues and by PSNS staff members. This mutually profitable interaction will, we hope, continue throughout the duration of the course trials.

Staff members who made especially valuable contributions to these sessions are the following:

(1) Elizabeth Wood, who led several stimulating discussions about the marvels of crystals and whose curiosity and powers of reasoning embody the spirit of the course.

(2) Earl Carlyon, our apparatus expert, who arranged to have the equipment for every experiment ready and working when needed, and whose own experiences as a teacher of PSNS he related with great enthusiasm.

(3) H.M. (Jim) Landis, the editor of our Resource Book for teachers, who provided many valuable suggestions to help the teachers and who received in return many more to help future generations of teachers.

(4) Richard Sakurai, our problem and examination writer, who presented us with more clever questions than we found time and skill to analyze adequately.

(5) and (6) Stanley Bunce and Lyman Racster, whose excellent knowledge of chemistry and experience as course authors filled in voids in my own qualifications as group leader.

The real credit for a successful briefing session, however, goes to an enthusiastic group of teachers who are willing to go that extra mile to provide meaningful science experiences for their students. They are listed below with institutional affiliations:

COOPERATING TEACHERS

Mrs. Shirley Aronson	Nassau Community College, Garden City, N.Y.
Lawrence W. Boothby	Green Mountain College, Poultney, Vermont
Brother James Donohue	Bishop Loughlin High School, Brooklyn
Earl L. Carlyon PSNS	State University College at Geneseo, New York
Donald Christian	University of Cincinnati, Cincinnati, Ohio
James D'Amario	Harford Jr. College, Bel Air, Md.
David Gavenda	University of Texas, Austin
Mrs. Israel E. Glover	Florida A.and M. University,Tallahassee, Florida
Z.L. Loflin	Fairleigh Dickinson University, Madison, N.J.
R.H. Mason	Mansfield State College, Mansfield, Pa.
Denver L. Prince	Arkansas State Teachers College, Conway
Richard Sakurai PSNS	Western College for Women, Oxford, Ohio
A.A. Silano	Newark State Teachers College, Union, N.J.
Sister J. Daniel	Villanova University, Villanova, Pa. Brooklyn Diocese, Brooklyn, New York
Sister M. Avila	College of Notre Dame of Maryland, Baltimore
Sister B. Handrup	Alverno College, Milwaukee, Wisconsin
Sister Paschal	College of St. Benedict, St. Joseph, Minnesota
M.K. Snyder	The Colorado College, Colorado Springs
Joseph Walka	Meramec Community College, St. Louis,Missouri
Stuart E. Whitcomb PSNS	Earlham College, Richmond, Indiana
N.E. White	Bloomsburg State College, Bloomsburg, Pa.
William LaShier	University of Kansas, Lawrence, Kansas

x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x

Figures 2 and 3 show some of these teachers in action during the August briefing session and Figure 4 is a map of the distribution of the pilot colleges during the academic year 1966-67. Each of these colleges receives free equipment for all experiments. In addition, about half the cost of the text is borne by the project. Neither of these subsidies will be continued after the current academic year.

Because of limitations both of budget and of operational procedure during this trial period, many colleges applying for participation in the program were not accepted for the year 1966-67.

Feedback

Some mention of feedback has already been made. Following is a further discussion by Professor H.M. Landis, Assistant Dean of Wheaton College, Norton, Massachusetts, who is in charge of PSNS feedback.

x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x

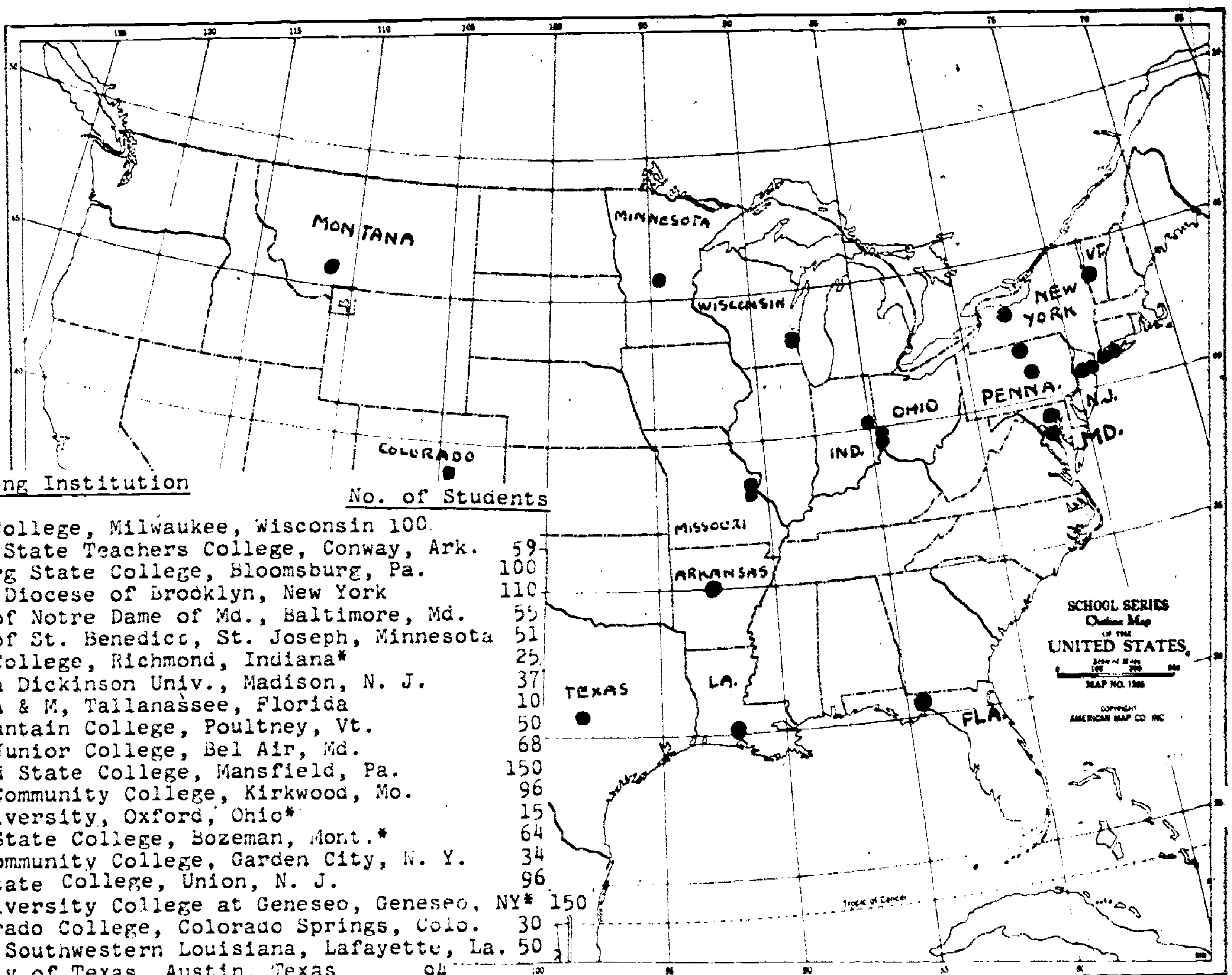
Feedback in the PSNS Project was begun the moment the project began. The summer staff at R.P.I. in 1965 was made up almost entirely of college teachers who had long been concerned with problems in science education; their reactions to the ideas and suggestions brought up in discussion were, from the very first, candid and instantaneous. As we progressed from the talking into the writing stage, we made somewhat more formal arrangements. The output of every contributor was duplicated and a copy put into each mail box. There were times when the volume of " first drafts" to be read reached staggering proportions, but read them we did, and then sent them back to their authors, copiously marked in red. And the informal face-to-face feedback continued unabated, from before breakfast until late coffee at Thornie's all night restaurant.

Figure 2

Figure 3

Figure 4

PSNS Cooperating Colleges, 1966-67



Cooperating Institution	No. of Students
Alverno College, Milwaukee, Wisconsin	100
Arkansas State Teachers College, Conway, Ark.	59
Bloomsburg State College, Bloomsburg, Pa.	100
Catholic Diocese of Brooklyn, New York	110
College of Notre Dame of Md., Baltimore, Md.	55
College of St. Benedict, St. Joseph, Minnesota	51
Earlham College, Richmond, Indiana*	25
Fairleigh Dickinson Univ., Madison, N. J.	37
Florida A & M, Tallahassee, Florida	10
Green Mountain College, Poultney, Vt.	50
Harford Junior College, Bel Air, Md.	68
Mansfield State College, Mansfield, Pa.	150
Meramec Community College, Kirkwood, Mo.	96
Miami University, Oxford, Ohio*	15
Montana State College, Bozeman, Mont.*	64
Nassau Community College, Garden City, N. Y.	34
Newark State College, Union, N. J.	96
State University College at Geneseo, Geneseo, NY*	150
The Colorado College, Colorado Springs, Colo.	30
Univ. of Southwestern Louisiana, Lafayette, La.	50
University of Texas, Austin, Texas	94
Webster College, Webster Groves, Mo.*	30
Western College for Women, Oxford, Ohio*	16

*Colleges that also taught PSNS 1965-66

The first feedback from the classroom came when school started in September 1965 and trial use of the course began at eight participating colleges. The reports were very personal and subjective. However, they did give us valuable information about the ways in which students reacted to our work. We had a discussion of the reports and impressions during a one-day meeting in January 1966. The first event of our second summer at R.P.I. was a week-long, page-by-page discussion and critique of the entire course and text by the first year trial teachers and the 1966 summer writing staff. All of this served as a guide for the real work of the summer: editing and revising the text, and beginning the Resource Book for teachers. Every step along the way was subjected to the same instant feedback as we had had during the previous year.

For our second year of trial teaching, involving about two dozen participating colleges, we developed a standard and fairly objective form for the instructors to use in evaluating each chapter as they completed it. The information we get will play a very important role in the final revision of the text next summer and in determining the form and content of the Resource Book. At present this book, in loose-leaf form, is a collection of background information, tips, explanations of text material, references and suggested problems; things that the staff felt the teacher might find useful in addition to what was in the text. (The one well-organized exception to this is an excellent set of very complete instructions for the preparation and carrying out of each of the experiments, almost entirely the work of Professor Earl Carlyon of State University College at Geneseo, New York.) The feedback information will not so much change all of this as it will help us to organize it more effectively and to

recognize the areas needing extra emphasis. We plan to get out a full preliminary edition of the Resource Book next summer. There is much to do, but we think we are on the right track.

x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x

Questions and Examinations

One of the big tasks which was not undertaken during the first summer was the preparation of suitable questions and problems to accompany each chapter as well as additional questions for use by the teacher as homework or examination questions. In addition, a pre-test, mid-test and post-test were to be administered by the teachers for the Project as a test of the course's achievement of its goals. Although many of the members of the Project have contributed to questions for all of these categories, the main burden of this task has rested upon Professor Richard Sakurai of Western College for Women, Oxford, Ohio. Professor Sakurai's report on this work follows.

x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x

One of the hardest tasks in the design of any new course is the design of homework problems and examinations. In this course, since the process by which we discover scientific knowledge is as important as the nature of the knowledge itself, the homework problems and the examinations cannot be of the standard types. We have tried to design homework problems not just to pursue the scientific concepts but also to stimulate further facility with the type of thought processes involved. For example, problems might involve the organization of new ideas, or the formulation of questions which occur in new situations and the design of experiments to shed light on these questions. One of the difficulties in writing such questions and

problems is in finding situations which are new, yet simple, and which can reasonably be expected to be solved by the type of student we have in this course.

A second difficulty is that such questions are best answered by essays in which the students have the freedom to discuss the problem and suggest various approaches to a solution. However, the task of correcting papers of this sort when the class is large places too heavy a burden on the instructor, especially if such questions are used on examinations. A type of question that can be marked quickly, such as a multiple-choice question, seems to be a necessity in such situations. Yet if we want our evaluation of the ability of the students to reason well in matters pertaining to physical science to be the primary consideration, a standard multiple-choice examination is unsatisfactory.

To get around this impasse, we have additionally designed what is, to us, a new type of examination question. We have written a two-part multiple-choice question. The first part gives a list of answers to the question itself. The second part gives a list of reasons for the answer. We have required that the choice for <u>both</u> parts be correct for the total answer to the question to be correct. This type of question is difficult to write, since we must not only try to think of all the answers which the students might reasonably select, but also all the types of reasoning they might use. We do think we have succeeded in doing this and that this type of examination could be graded quickly. The following is a sample question.

A rowboat made entirely of wood _____ made to sink to the bottom by putting water in it, because_____.

(a) can be (b) cannot be (c) can sometimes be

(1) The combination of boat plus water weighs more than enough.

(2) The density of the combination of boat plus water can be varied by varying the amount of water added.

(3) The density of wood is less than the density of water.

(Answer: b3)

One of the ways in which students judge a course is by the material emphasized in homework assignments and examinations, since the students assume that these indicate much of what we want them to take from the course. This means that we as the designers and instructors of the course have a special responsibility in our choice of homework and examination questions.

Much of the success or failure of the student's response to these questions will be evident only to the individual instructor, as he is the only one who knows the context in which these questions are given. The PSNS staff has felt that it would be desirable to have a single examination, taken by all students as a test of the course materials. Therefore, in addition to the questions and problems and suggested examination questions supplied to the teacher for his own use, we have designed a series of uniform "evaluation tests" to be given the students in all the participating colleges. These tests contain simple multiple-choice questions, but some of the questions are designed to find out how much they know about scientific thinking processes. For example, we present a common everyday situation and then ask them to choose from a list of questions those that would be appropriate questions to ask if we wanted to learn more about the given situation. In some cases more than one choice is appropriate.

This has been a most interesting job for me, as it necessarily involves careful and penetrating consideration of the real aims of the course.

x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x-x

Attitude Evaluation by an Independent Agent

Since a major goal of the project is attitude reorientation, it would have been desirable to enlist a professional testing service in an effort to determine whether changes of attitude toward science were, in fact, achieved. The assurance of continued support from from the National Science Foundation was not received in time for us to contract for such services this year.

Summer Institute

During the summer of 1967, an eight-week Summer Insititute in physical science will be held at Rensselaer Polytechnic Institute, with Professor Arnold A. Strassenburg of Stony Brook and Professor Stanley C. Bunce of R.P.I. as co-directors. Professor Strassenburg will act as chief instructor, assisted by Professor Bunce of the Chemistry Department, Professor Wilfred E. Campbell, Chemistry of the Materials Engineering Department of R.P.I., and Professor Robert L. Sells of the Physics Department of the State University College at Geneseo, New York.

Attendance at this Institute will not be limited to those who plan to teach the PSNS course the following year, but it is anticipated that many of those attending the Institute will be PSNS instructors. Special classes will be given in chemistry for those whose background is stronger in physics, and in physics for those whose background is stronger in chemistry. It is hoped that this will facilitate

the teaching of an integrated physical science course by a single instructor, a result desirable for any course in physical science.

Those interested in participation in this summer institute should write immediately to:

Professor A.A.K. Booth, Director
Division of Special Programs
Rensselaer Polytechnic Institute
Troy, New York, 12181

The application forms which will be sent in response to such an inquiry must be filed by February 15 to insure consideration.

Future Plans

The directors of the PSNS Project plan to have the text materials available in a third preliminary edition for the fall of 1967 and the final edition, accompanied by a Resource Book, will be in the hands of a commercial publisher by the fall of 1968. The equipment for experiments will be commercially available from one or more suppliers. Neither the equipment nor the text will be subsidized by the project after June 1967. Equipment costs are likely to be about $30 per student and the cost of the text probably under ten dollars.

During the briefing session in August 1966, it became clear that discussion with PSNS staff members and fellow teachers was of great value in clarifying the philosophy of the PSNS approach and that without such contacts the 1966-67 teachers might have had difficulty because of trying to teach this new course in the way they had previously taught physical science. Hopefully, the instructor's Resource Book will contain a

sufficiently full discussion of the PSNS approach to enable a future teacher to proceed without the benefit of such face-to-face discussions, but it may be that further briefing sessions and institutes will be desirable.

At present the plan is to welcome a wider expansion of the use of the course during the year 1967-68. Those interested in participating in this use should write, before March 1, to:

Professor Arnold A. Strassenburg
State University of New York at Stony Brook
Stony Brook, New York

Additional copies of this Newsletter may be obtained from

Professor Lewis G. Bassett
Rensselaer Polytechnic Institute
Department of Chemistry
Troy, New York, 12181

The PSNS Project Newsletter No. 3
December 1967

Many of you who read this PSNS Newsletter No. 3 will already be familiar ~~with~~ the PSNS project, with the course, and with its philosophy of teaching. For you, we hope this Newsletter will be a meeting of good friends. For those of you who are not acquainted with or know but little of the PSNS course, we hope to introduce this course to you with this Newsletter.

It has long been recognized that many of the students who are not science majors feel some antagonism toward science. If they do not feel antagonism, they may feel a fear of science, or, at best, they have feelings of detachment from science. Yet many of the college students who fall in this category are preparing to become teachers in the elementary schools. If those students carry these negative feelings of science on with them, then, as teachers, they will propagate those feelings to their young students. These teachers will be unprepared or unable to teach a unit in science which excites the imagination of their students. The elementary students are very apt to acquire their teacher's negative feelings and attitudes toward science. The process is circular in nature; teachers influence students who later become teachers.

It was with hope of breaking into that circular process that a series of conferences were held in 1963 and 1964. These conferences were sponsored jointly by the Commission on College Physics and the Advisory Council for College Chemistry. The primary result of these conferences was the formation of a project to develop a course in physical science at the college level which would interest the nonscience student rather than frighten him. That project, called the PSNS Project (Physical Science for Nonscience Students), is now in the final year of its preparation of a course designed to

present physical science to the nonscience student with a significantly new approach. Although the approach may be new to science teaching it is not new to science.

The PSNS Project was formed in 1965 and since that time it has been supported by the National Science Foundation, and has enjoyed the physical facilities of Rensselaer Polytechnic Institute in Troy, New York. The members of the advisory board and staff who created the course are listed at the end of the Newsletter.

The Purpose of the PSNS Course

The purpose of the PSNS course is to present physical science to nonscience students in a way that interests them rather than antagonizes them. The course should spark curiosity rather than fear in the student.

The original intent was to encourage the future elementary school teachers to embark on an exciting unit in science. That original intent has been preserved and extended. The course is still directed to the student who shies away from science, but it has been used in a variety of institutions to satisfy a number of demands. In addition to being used in teacher training courses, it is being used to satisfy the science requirement for graduation from colleges and universities. It is also being used in a number of two-year colleges. It has been used for in-service training of teachers. The expanded use of the course has not altered either its purpose, its nature, or its effectiveness. The value of its purpose has been proven; the key to its effectiveness is the teacher.

The Nature of the Course

Science progresses by building models based on observations, then using

those models to make predictions, and finally, by experiment, testing to determine whether those predictions are borne out by further observations. Eventually the scientific world tries to formulate general statements each of which describes a wide variety of observable phenomena. The PSNS course strives to do the same. The approach of the course is empirical. The student is supplied with relatively simple equipment and more often than not is encouraged to devise his own methods to seek out the observations which will be the basis for building a model of the particles which comprise a gas, for example, or a model of a crystal, or of some other aspect of matter.

It has been the intent of the project to avoid an encyclopedic type of course. It is recognized that no one can teach all of physics, chemistry, astronomy, and geology in one year to the nonscience student. Every physical science instructor must select those portions of the subject which he thinks will either interest his students or be the most significant to them. More often than not, however, what the instructor teaches depends upon his own background and interests. The PSNS staff chose to direct the student's attention to the structure of solid matter, with initial emphasis on the ionic crystal. The course draws on those aspects of physics and chemistry which are needed to build a working model of solid matter. By restricting the amount of subject material covered, the PSNS course is able to probe in greater depth.

The choice of solid matter as a framework for the course was made for practical reasons. The study of solid matter involves both chemistry and physics, and it can be easily extended to include geology and astronomy. In addition, the study of ionic crystals provides many simple yet significant laboratory experiments which the students can perform.

Since the course is not encyclopedic in nature, it is easier for the

teacher to avoid the stereotyped lecture-lab course. PSNS is not a ''Student, you listen to me!'' course; it is a ''Student, let's think together!'' course. The teacher is more effective if he enlists the student's natural curiosity to develop the ideas and models required. The teacher is encouraged not to tell the students ''all about it,'' rather the teacher is encouraged to elicit questions from the students. Very often these probing questions will lead to the formulation of a model that satisfies the requirements set forth by the class. The learning is done by the students as they, with the help of the teacher, probe the subject being discussed. There is a lot of class discussion, a lot of give and take between the student and the teacher. This type of approach, of course, works much better with a class of 24, for example, than it does with a class of 150; but both have been tried.

If the laboratory experiments are going to be used to build models, then those experiments must be well chosen. The equipment, built by Damon Educational, Inc., is specially designed to enhance the effectiveness of the course. For example, crayons and color filters are well matched; a mark on white paper by one of the red crayons cannot be seen by looking through the red filter.

If the experiments are such an important part of the course, they must be discussed by the class. Not all of the students will obtain the same results and the differences in their results should be discussed. The PSNS staff feels that not all experiments should go like clock work. Science isn't like that.

By avoiding sophisticated equipment the students can become aware that ideas, significant ideas, can be developed from experiments using simple equipment- equipment that might be found in any elementary school classroom, for example. Most of the experiments are performed in the laboratory, but

all can be performed on a smooth table with a supply of water and a sink nearby. Among those experiments requiring heat, an alcohol burner will suffice for all but a few. An example of a PSNS laboratory experiment is the determination of electrical conductivity of substances as a solid, as a melt, (for those which melt at convenient temperatures), and in aqueous solution (for those which dissolve in water). The materials are classified as having: (1) a high conductivity, (2) a low conductivity, and (3) a negligible conductivity. For this purpose a flashlight bulb is used instead of an ammeter. The conductivity of matter is used to help build first a model of the ionic crystal, and later a model of nonionic material.

Some experiments are ''take-home'' experiments. The student is either given the equipment or is asked to supply his own simple equipment, and the experiment is performed outside the classroom. An example of a take-home experiment is the flipping of one-hundred coins in a box to illustrate the law of entropy. This experiment is used to help understand the melting and dissolving of a crystal on a microscopic level.

Other experiments are what we call ''chair-arm'' experiments. (Significantly, the term is chair-arm not arm-chair.) The chair-arm experiments can be done in the classroom rather than in the lab, and the results can be discussed right then and there. One chair-arm experiments is the melting and growing of salol crystals. Magnifying lenses are supplied for this and other experiments.

Some of the 60 experiments in the course have been designated demonstration experiments. These experiments are either safer, significantly less expensive, or more effective when done as a demonstration. One example of a demonstration experiment is the chemical combining of zinc and iodine during which iodine vapor is liberated rather freely. Another example of a demon-

stration experiment is the tying of four balloons together to help the student visualize the tetrahedral shape of the cloud model of the carbon atom.

The equipment has been built to be effective, unsophisticated, and not expensive. It is estimated that for the first year of using PSNS, the cost per student will be about 30 dollars depending on the number of sections. For succeeding years when only the expendable equipment will be purchased, the cost per student is estimated to be only about 10 dollars. The entire course can be taught with this equipment, but some teachers have supplemented the PSNS equipment with equipment they already have. One guideline of the PSNS course is to avoid overwhelming the student with very sophisticated and mystifying equipment.

Mathematics is used when it is needed, but rather than being a problem solving course, it is a model building course. Bragg's law is used to illustrate how the lattice spacing in a crystal is measured. Kinetic and potential energy are expressed mathematically. The mathematics is used primarily to illustrate the fact that many ideas can be expressed more simply when written mathematically than when written in English.

Because the course is limited in its coverage, a number of supplementary chapters are being prepared to be used along with the text. These supplementary chapters will cover a variety of subjects not covered in the "main stem" of the course, such as: geology, astronomy, magnetism, and acids and bases. They may be used by the teacher to supplement and extend the class work in a number of ways. The teacher may choose to have the entire class study one or more supplementary chapters, or he may let students who proceed faster than the rest of the class study a supplementary chapter, and he may even have those students report to the class. It is the purpose of the supplementary chapters to provide a more flexible course; no two teachers teach exactly the same course.

Progress of the Project

The course is now in its third year of development. During the academic year 1965-66 it was used at eight colleges (listed at the end of this Newsletter) and during the year 1966-67 it was used at 23 colleges and universities. The instructors at each of those colleges agreed to supply the writing staff with their comments, critical or otherwise, on the text, the experiments, and the laboratory equipment. This feedback from the teachers was given both in writing and in a series of feedback sessions. During each of these feedback sessions the teachers and the writing staff sat together and hashed out the text chapter by chapter over a period of several days. Large portions of the text, some of the experiments, and some of the equipment were changed during the writing of the 2nd preliminary edition, and again in the 3rd preliminary edition. Most of these changes were made in response to the teacher's suggestions.

The staff feels that with some minor changes, the course is now well developed. These minor changes will be made during the current academic year in preparation for the final version. The third preliminary edition and the final version of the text are being published by John Wiley and Sons, Inc., N.Y.

Teacher's Resource Book

Since the course is different from other physical science courses, and, more important, since the approach required to teach it successfully is different, the PSNS staff is preparing a Teacher's Resource Book. This book discusses the text, section by section, chapter by chapter. Reasons are given for the arrangement of subject matter and the thread of thought is discussed. Suggestions for teaching methods and suggestions for discussions that go beyond the text are given. If a particular development is treated

only lightly in the text, that development is often presented in more detail in the Resource Book, or at least the teacher is told why it is not discussed in detail.

The experiments are discussed in detail in the Teacher's Resource Book and helpful suggestions are given the teacher. The teacher is warned of any difficulties that might arise with an experiment and where the students might go astray.

The questions and problems which appear throughout the text are answered and discussed in the Teacher's Resource Book. If the problem has a numberical solution, that solution is given. If the question calls for a discussion, the pertinent points of that discussion are given. Often, the reasons for including a particular question or problem are given.

A film bibliography accompanies each chapter of the Resource Book and an annotated bibliography to other books is included.

Reaction to the PSNS Course

Student and teacher reaction to the approach offered by the PSNS course has been very favorable. It is interesting that during the first two or three weeks of the course, students feel uneasy and insecure. They haven't been given all kinds of stuff to memorize, they haven't been asked to work problem after problem; they have been asked to observe and to think. The student worries how he is going to be evaluated; it would appear that very few students have ever had a course of this nature before. However, as the semester proceeds, the students begin to understand and appreciate the approach; they begin to study differently than they had before. One teacher was told by one of his students that the PSNS course changed her study habits for all of her classes. During that semester she made the Dean's honor roll for the first time.

Many of the students who entered the course with a fear of physical science find that they actually enjoy the course. ''To be perfectly honest, I still don't care for science as much as for the other fields, but at least I don't dread coming for this class as I dreaded high school chemistry.'' ''Physics, that ominous and terrifying course which I was fearful of taking, has suddenly become the most interesting and exciting course I have taken in science.''

Student evaluation is more difficult in this course than in standard physical science courses. Questions which call for a brief but written discussion by the student are of even greater value to the teacher and student of PSNS than in a standard course. Objective-type questions, although not entirely inappropriate, must be written very carefully. Extensive memorization of facts is not a useful study technique for this course.

Teacher reaction to the PSNS course can be demonstrated by pointing out that the opening of one of the feedback sessions was postponed by teachers spontaneously expressing their enthusiasm over this approach. This is not to say that teaching PSNS is easy. In fact, most of the teachers agreed that at least for the first year or so, it is more difficult to teach than a standard course in physical science. It is difficult because the approach is different; the teacher has to reorient his thinking. His ''lecture notes'' are not lecture notes; they are not apt to be an outline of the subject to be discussed that day, an outline that guides <u>his</u> lecture to the near neglect of the student. The teacher's notes are more apt to include guides for him that will enable him to draw questions from the students, guides to stimulate discussions. Maybe the course could be called a dialogue between the teacher and the class.

But if it is more difficult to teach PSNS than a standard physical science course, the teachers find it more gratifying. The students really do become interested, they really do observe when they used to watch. They really do enjoy offering suggestions to build a model of the crystal, or of the particles in a gas.

One of the current PSNS teachers, Sister M. Beata Ruggle, SAC, at Marillac College, St. Louis, Missouri, writes:

> I enjoy teaching the PSNS course, more so than any other science or math course that I ever taught in any of my 25 years of teaching experience. And I always liked teaching. The integration of lab and lecture has been achieved in PSNS. The students appreciate this aspect very much.

Summer Institute

Under a grant from the National Science Foundation an institute was held during the summer of 1967 at the Rensselaer Polytechnic Institute in Troy, New York with a two-fold purpose. The PSNS course, its philosophy and content were discussed completely and in detail. In addition there were sessions in physics and chemistry held each day for prospective PSNS teachers to brush up and extend their knowledge in one of the two fields. Teachers with a strong background in physics attended the chemistry section, and vice versa. The teachers who attended the institute feel much better prepared to teach the PSNS course in particular and physical science classes in general.

It is hoped that there will be another institute at RPI during the summer of 1968.

For information about the course and the summer institute write to:

Professor A. A. Strassenburg
Department of Physics
State University of New York
Stony Brook, New York 11790

PSNS Materials

A brochure on the course and materials, and a catalog of the laboratory equipment are now being prepared by John Wiley and Sons, Inc. You can obtain copies of the brochure and catalog, and should you be considering the adoption of PSNS, you may also receive a copy of the text and the Teacher's Resource Book by writing to:

Mr. Tom Sears
John Wiley and Sons, Inc.
605 Third Avenue
New York, N.Y. 10016

Information copies of the Teacher's Resource Book and additional copies of this Newsletter may be obtained by writing to:

Dr. Lewis G. Bassett
Department of Chemistry
Rensselaer Polytechnic Institute
Troy, New York 12181

The PSNS Staff

Most of the work on the project has been done during the summers, although a good deal of work has also been done during the academic year. Earl Carlyon continues to work on the experiments and equipment, and works closely with the staff of Damon Educational, Inc. H.M. Landis continues his work on the Teacher's Resource Book. This year is different from the previous years, however, for the book is going into final production. Because of this increased load, Stuart Inglis has obtained a leave of absence from Chabot College in California and works in New York full time on the project. He works closely with the staff of John Wiley and Sons, Inc. guiding the book into production.

The personnel of the PSNS Project are:

A. Members of the Advisory Board

Lewis G. Bassett, Rensselaer Polytechnic Institute (1964-68)

Walter E. Eppenstein, Rensselaer Polytechnic Institute (1967-68)

Donald F. Holcomb, Cornell University (1966-68)

Alan N. Holden, Bell Telephone Laboratories (1964-68)

Frank R. Kille, New York State Department of Education (1964-68)

Arthur H. Livermore, American Association for the Advancement of Science (1964-68)

Charles C. Price, University of Pennsylvania (1964-68)

Robert Resnick, Rensselaer Polytechnic Institute (1964-68)

Rober L. Sells, State University of New York College at Geneseo (1964-68)

Arnold A. Strassenburg, State University of New York at Stony Brook and American Institute of Physics (1966-68), Chairman of the Board, 1966-68.

James H. Werntz, University of Minnesota (1966-68)

Elizabeth A. Wood, Bell Telephone Laboratories (1964-68) Chairman of the Board, 1964-66.

B. PSNS Staff (Dates refer to summer writing conferences)

Director: L. G. Bassett, Rensselaer Polytechnic Institute (1965, 66, 67)

Codirector: W. E. Eppenstein, Rensselaer Polytechnic Institute, Troy, New York (1967)

Associate Directors: R. L. Sells, State University of New York, College at Geneseo (1965, 66, 67)

A. A. Strassenburg, State University of New York at Stony Brook (1966, 67)

E. A. Wood, Bell Telephone Laboratories (1965, 66, 67)

S. F. Aronson, Nassau Community College, Garden City, New York (1967)

J. J. Banewicz, Southern Methodist University, Dallas, Texas (1965)

S. C. Bunce, Rensselaer Polytechnic Institute, Troy, New York (1965, 66)

W. E. Campbell, Rensselaer Polytechnic Institute, Troy, New York (1965)

E. L. Carlyon, State University of New York at Geneseo, Geneseo, New York (1965, 66, 67)

M. T. Clark, Agnes Scott College, Decatur, Georgia (1966)

T. H. Diehl, Miami University, Oxford, Ohio (1965)

W. E. Eppenstein, Rensselaer Polytechnic Institute, Troy, New York (1967)

D. F. Holcomb, Cornell University, Ithaca, New York (1966)

H. B. Hollinger, Rensselaer Polytechnic Institute, Troy, New York, (1967)

S. J. Inglis, Chabot College, Hayward, California (1966, 67)

J. L. Katz, Rensselaer Polytechnic Institute, Troy, New York (1965)

H. M. Landis, Wheaton College, Norton, Massachusetts (1965, 66, 67)

S. H. Lee, Texas Technological University, Lubbock, Texas (1965)

A. Leitner, Rensselaer Polytechnic Institute, Troy, New York (1967)

W. J. McConnell, Webster College, Webster Groves, Missouri (1966)

H. F. Meiners, Rensselaer Polytechnic Institute, Troy, New York (1965)

E. J. Montague, Ball State University, Muncie, Indiana (1965)

L. V. Racster, Rensselaer Polytechnic Institute, Troy, New York (1965, 66, 67)

A. J. Read, State University of New York at Oneonta, Oneonta, New York (1965)

R. Resnick, Rensselaer Polytechnic Institute, Troy, New York (1965, 66)

F. J. Reynolds, West Chester State College, West Chester, Pennsylvania (1965)

R. K. Rickert, West Chester State College, West Chester, Pennsylvania (1965, 66, 67)

R. S. Sakurai, Webster College, Webster Groves, Missouri (1965, 66, 67)

J. Schneider, St. Francis College, Brooklyn, New York (1966)

L. Smith, Russell Sage College, Troy, New York (1965, 66, 67)

A. A. Strassenburg, State University of New York at Stony Brook and American Institute of Physics (1966, 67)

P. Westmeyer, Florida State University, Tallahassee, Florida (1965, 66, 67)

S. E. Whitcomb, Earlham College, Richmond, Indiana (1966, 67)

E. Wright, Montana State College Bozeman, Montana (1965)

E. A. Wood, Bell Telephone Laboratories, Murray Hill, New Jersey (1965, 66, 67)

The Trial Colleges and Instructors (Numbers in parentheses are approximate numbers of students

A. During the academic year 1965-66

Ball State University, Muncie, Indiana; E. J. Montague (880)

Earlham College, Richmond, Indiana; S. E. Whitcomb (20)

Miami University, Oxford, Ohio; T. H. Diehl (20)

Montana State College, Bozeman, Montana; N. Kutzman (30)

State University of New York College at Geneseo, New York; E. L. Carlyon (150)

Webster College, Webster Groves, Missouri; W. J. McConnell (30)

West Chester State College, West Chester, Pennsylvania; R. K. Rickert (40)

Western College for Women, Oxford, Ohio; R. S. Sakurai (10)

B. During the academic year 1966-67

Alverno College, Milwaukee, Wisconsin; Sister B. Handrup (100)

Arkansas State Teachers College, Conway, Arkansas; D. L. Prince (59)

Bloomsburg State College, Bloomsburg, Pennsylvania; N. E. White (100)

Catholic Diocese of Brooklyn, New York; Brother J. Donohue, Brother Gratian Ohmann, Sister J. Daniel (110)*

College of Notre Dame of Maryland, Baltimore, Maryland; Sister M. Avila (55)

College of St. Benedict, St. Joseph, Minnesota; Sister Paschal (50)

Earlham College, Richmond, Indiana; S. E. Whitcomb (25)

Fairleigh Dickinson University, Madison, New Jersey; C. Grove (40)

Florida A and M, Tallahassee, Florida; Mrs. I. E. Glover (10)

Green Mountain College, Poultney, Vermont; L. W. Boothby (50)

Harford Junior College, Bel Air, Maryland; J. D'Amario (70)

Mansfield State College, Mansfield, Pennsylvania; R. H. Mason (150)

Meramec Community College, Kirkwood, Missouri; J. Walka (1^0)

Miami University, Oxford, Ohio; T. H. Diehl (15)*

Montana State College, Bozeman, Montana; N. Kutzman (65)

Nassau Community College, Garden City, New York; S. Aronson (35)

Newark State College, Union, New Jersey; A. A. Silano, J. Wagner (100)

State University College at Geneseo, Geneseo, New York; E. L. Carlyon, R. L. Sells (150)

The Colorado College, Colorado Springs, Colorado; M. K. Snyder (30)

University of Southwestern Louisiana, Lafayette, Louisiana; Z. L. Loflin (50)

University of Texas, Austin, Texas; D. Gavenda, R. Anderson (95)

Webster College, Webster Groves, Missouri; W. J. McConnell (30)

Western College for Women, Oxford, Ohio; R. Sakurai (16)

C. The present academic year 1967-68

There are no trial colleges at present. Now that the text is published by a commercial publishing house in its essentially final revision, any college may introduce the course into its curriculum. Both written (text and resource book) and experimental materials may be ordered from the publisher, John Wiley and Sons, Inc. At present about 2400 students are taking the PSNS course in 36 institutions scattered throughout the country.

*In-service course

The PSNS Project Newsletter No. 4
January 1969

Introduction

This is the last Newsletter written by the PSNS staff to describe the Project. National Science Foundation support will terminate in June 1969, about four years from the date of its initiation. This is in accordance with the original plan to push the bird out of the nest as soon as it could fly. There are now over 10,000 PSNS students using the Third Preliminary Edition of An Approach to Physical Science, according to the latest figures from John Wiley and Sons, the publishers who are handling the distribution of course materials. Most of the staff goals have been achieved. The present status of various project activities are described below.

Publication Plans

Text: The first hard-cover edition of the text is expected to appear as one volume late in January 1969. It has been produced by John Wiley and Sons with the closest collaboration of members of the PSNS staff. Its final form results from detailed editorial work by Professor Lewis G. Bassett, Director of PSNS, and Professor Arnold A. Strassenburg, Associated Director and Chairman of the Advisory Board. This edition will be presented in a more attractive format than the preliminary editions; it will be copiously illustrated and handsomely printed in two colors. It will retain most of the essential characteristics of previous editions such as choice of topics, style of presentation, simplicity of experiments, open-endedness of questions, and pace.

Teachers Resource Book

The Teachers Resource Book, which is thicker than the text, will be available in February 1969. It will be provided free of charge to any teacher teaching the course.

The purpose of the Teachers Resource Book is fourfold.

1. It provides a chapter-by-chapter rationale for the selection and ordering of subject matter, and also suggests teaching techniques which are in harmony with the overall philosophy of the course.
2. It supplies detailed discussion of and answers to all questions and problems presented in the text.
3. It lists all apparatus needed to perform each experiment included in the text, and provides helpful hints to guarantee satisfactory experimental results.
4. It includes references to ancillary materials which can help the teacher enrich student experiences. Prominent among these are references to specific pages in other books which treat course topics and an extensive, annotated film guide.

The PSNS Teachers Resource Book and the text An Approach to Physical Science can be ordered directly from John Wiley and Sons, 605 Third Avenue, New York, New York 10016. The retail price of the text is $8.95.

Supplementary Chapters

Supplementary chapters on four topics have been prepared: Acids and Bases, Magnetism, Matter in the Astronomical Realm, Matter in the Earth. While they last, a limited number of copies of these in preliminary form may be obtained from Professor L. G. Bassett, Department of Chemistry,

Rensselaer Polytechnic Institute, Troy, New York 12181.

During the 1969-70 academic year, teachers who wish to use these chapters will have to provide their own equipment. With few exceptions this will present no insurmountable problems to a teacher with a moderately well-stocked storeroom.

These chapters are being revised and will be published by Wiley, probably in a single book separate from the main text, about one year from now. By that time all equipment needed to perform the associated experiments will also be available from Wiley.

There are additional supplementary chapters still in manuscript form which may ultimately be included with these four. In accordance with the original plan, however, it is anticipated that the number of supplementary chapters will be kept small. It is hoped that they will add flexibility to the course, but they are meant to supplement, not distract from, the mainstem text.

Descriptive Brochures

John Wiley and Sons have produced two attractive brochures. One describes the general nature of the course and lists the table of contents of the text. The other describes and pictures the equipment associated with each experiment and gives a price list and ordering instructions. These can be obtained free of charge directly from Wiley. A description of the PSNS course was published in the October 1968 Newsletter of the Commission on College Physics. Reprints of this are available from John Wiley and from Elizabeth A. Wood, 37 Pine Court, New Providence, N.J. 07974.

Newsletters

A few copies of former Newsletters are still available. These and copies of Newsletter No. 4 can be requested from Prof. Bassett, address above, or Prof. A. A. Strassenburg, Department of Physics, State University of New York at Stony Brook, Stony Brook, New York 11790.

Equipment

Orders for equipment, which is provided by Damon Engineering Company's Educational Division, are processed by John Wiley. At least one other apparatus supplier has advertised his intention to supply PSNS equipment. PSNS apparatus is simple and inexpensive. The equipment needed for 100 students costs about $30 per student the first year; replenishment of expendables in subsequent years will be about one-third the initial cost. A catalogue (described earlier) can be obtained from Wiley.

Teacher Institutes and Briefing Sessions

Summer Teacher Training Institutes, with funding by NSF separate from that of the PSNS Project, were held at Rensselaer Polytechnic Institute during the Summers of 1967 and 1968 under the joint directorship of Professor S.C. Bunce of RPI and Professor A. A. Strassenburg of the State University of N.Y. at Stony Brook. Three proposals for 1969 Summer Institutes of similar pattern were presented to NSF by other colleges. It is now known that none of these will be funded by NSF.

John Wiley has agreed to support two- or three-day briefing

sessions for prospective PSNS teachers, and various members of the PSNS staff have agreed to participate in these sessions. If several college physical science teachers in your region are interested in becoming more familiar with the PSNS materials and the philosophy of the course, we suggest you register this interest by writing either Mr. Andrew Ford, John Wiley and Sons, 605 Third Avenue, New York, N.Y. 10016 or Professor A.A. Strassenburg, address given earlier.

Historical Summary

Since this is the final PSNS Newsletter, it seems appropriate to review briefly the history of the project. For convenient reference, this summary is presented in tabular form below, followed by a list of the project personnel and their dates of service.

Project Personnel

Advisory board:

Lewis G. Bassett, Rensselaer Polytechnic Institute (1964-69)

Walter E. Eppenstein, Rensselaer Polytechnic Institute (1967-69)

Donald F. Holcomb, Cornell University (1966-69)

Alan N. Holden, Bell Telephone Laboratories (1964-69)

Frank R. Kille, New York State Department of Education (1964-69)

Arthur H. Livermore, American Association for the Advancement of Science (1964-69)

Charles C. Price, University of Pennsylvania (1964-69)

Robert Resnick, Rensselaer Polytechnic Institute (1964-69)

Robert L. Sells, State University of New York College at Geneseo (1964-69)

Arnold A. Strassenburg, State University of New York at Stony Brook and American Institute of Physics (1966-69), Chairman of the Board, 1966-69.

Date	Event	Publications			Equipment
		Text	Teachers Resource Book	Supplemtary Chapters	
April 1965	Project initiated at RPI with NSF funding				
Summer 1965	First writing conference				
Winter 1965-6	PSNS tried by 8 colleges	1st Prelim. Ed. completed and in use.	Personal letters	None	Produced and distributed by staff
Summer 1966	Second writing conference	2nd Prelim. Ed. completed and in use.			Produced and distributed by Damon
Winter 1966-7	PSNS tried by 23 colleges	3rd Prelim. Ed. in preparation.	1st Ed. (not all chapters covered)	Acids and Bases	
Summer 1967	Third writing conference First Summer Institute	3rd Prelim. Ed. completed and in use			Produced by Damon; distributed by Wiley
Winter 1967-8	PSNS used by about 50 colleges	Final Ed. in preparation.	2nd Ed. (all chapters covered)	Magnetism	
Summer 1968	Fourth writing conference Second Summer Institute	3rd Prelim. Ed. still in use.	2nd Ed. still in use.	Matter in the Earth	Produced by Damon; distributed by Wiley
Winter 1968-9	PSNS used by more than 10,000 students	Final Ed. completed and published	3rd Ed. completed and published.	Matter in the Astronomical Realm	
June 1969	Project terminated				

James H. Werntz, University of Minnesota (1966-69)

Elizabeth A. Wood, Bell Telephone Laboratories (1964-69) Chairman of Board, 1964-66.

Directors and Associate Directors: (Dates refer to summer writing Conferences)

Director: L. G. Bassett, Rensselaer Polytechnic Institute (1965, 66, 67, 68)

Codirector: W. E. Eppenstein, Rensselaer Polytechnic, Troy, New York (1967,68)

Associate Directors: R. L. Sells, State University of New York, College at Geneseo (1965, 66, 67)

A. A. Strassenburg, State University of New York at Stony Brook (1966, 67, 68)

E. A. Wood, Bell Telephone Laboratories (1965, 66, 67, 68)

Staff: (Dates refer to summer writing conferences)

S. F. Aronson, Nassau Community College, Garden City, New York (1967,68)

J. J. Banewicz, Southern Methodist University, Dallas, Texas (1965)

S. C. Bunce, Rensselaer Polytechnic Institute, Troy, New York (1965, 66, 67)

W. E. Campbell, Rensselaer Polytechnic Institute, Troy, New York (1965)

E. L. Carlyon, State University of New York at Geneseo, Geneseo, New York (1965, 66, 67, 68)

M. T. Clark, Agnes Scott College, Decatur, Georgia (1966)

T. H. Diehl, Miami University, Oxford, Ohio (1965)

W. E. Eppenstein, Rensselaer Polytechnic Institute, Troy, New York (1967, 68)

D. F. Holcomb, Cornell University, Ithaca, New York (1966)

H. B. Hollinger, Rensselaer Polytechnic Institute, Troy, New York (1967, 63)

S. J. Inglis, Chabot College, Hayward, California (1966, 67, 68)

J. L. Katz, Rensselaer Polytechnic Institute, Troy, New York (1965)

H. M. Landis, Wheaton College, Norton, Massachusetts (1965, 66, 67, 68)

S. H. Lee, Texas Technological University, Lubbock, Texas (1965)

A. Leitner, Rensselaer Polytechnic Institute, Troy, New York (1967)

W. J. McConnell, Webster College, Webster Groves, Missouri (1966)

H. F. Meiners, Rensselaer Polytechnic Institute, Troy, New York (1965)

E. J. Montague, Ball State University, Muncie, Indiana (1965)

L. V. Racster, Rensselaer Polytechnic Institute, Troy, New York (1965, 66, 67, 68)

A. J. Read, State University of New York at Oneonta, Oneonta, New York (1965)

R. Resnick, Rensselaer Polytechnic Institute, Troy, New York (1965, 66)

F. J. Reynolds, West Chester State College, West Chester, Pennsylvania (1965)

R. K. Rickert, West Chester State College, West Chester, Pennsylvania (1965, 66, 67)

R. S. Sakurai, Webster College, Webster Grooves, Missouri (1965, 66, 67, 68)

J. Schneider, St. Francis College, Brooklyn, New York (1966)

L. Smith, Russell Sage College, Troy, New York (1965, 66, 67, 68)

A. A. Strassenburg, State University of New York at Stony Brook and American Institute of Physics (1966, 67, 68)

P. Westmeyer, Florida State University, Tallahassee, Florida (1965, 66, 67)

S. E. Whitcomb, Earlham College, Richmond, Indiana (1966, 67, 68)

E. Wright, Montana State College, Bozeman, Montana (1965)

E. A. Wood, Bell Telephone Laboratories, Murray Hill, New Jersey (1965, 66, 67)

Evaluation

The Directors and Associate Directors of the PSNS Project have been trying to make arrangements for an objective evaluation of its achievements by some person or organization not associated either with the production or use of the materials. This effort is continuing. John Wiley tells us that the text is "a best seller in its first year - which is exceptional." This may indicate that the materials are filling a need that was felt by those teaching the nonscience student; it certainly indicates that there was a need that was widespread.

One of our primary objectives is to improve the attitudes of nonscience students toward science. We know students respond favorably to the course while they are enrolled. Whether or not lasting attitudes toward science generally are altered is a more difficult matter to assess, but we do intend to have this matter explored as objectively as possible during the first year in which final editions of our materials will be in use.

PSNS Materials Put to a Severe Test

The Institute for Services to Education is engaged in an ambitious project involving thirteen predominantly Negro colleges. Approximately 100 students at each school have volunteered to enroll in a special curriculum designed to provide liberal arts courses and special skills experiences for the students instead of specialized freshman and sophomore courses leading to a degree in a particular discipline.

We are pleased to report that PSNS materials have been selected by the Curriculum Research Group, and seem to be serving the needs of

the science teachers and their students reasonably well. It is especially pleasing to be able to report that one of the most imaginative uses of the PSNS materials that we have heard about has been developed at Lincoln University in Pennsylvania, one of the schools participating in the ISE project. We quote below from a letter from Professors Christensen and Johnson of Lincoln:

> As we explored the chapter on solids dealing with solubility, several questions were raised by the students. Some students wanted to know whether more salt dissolved than sugar at room temperature. Growing out of this study of crystalline solids and their structural units, other questions were apparent - does this disappearance of these units in water remain the same with an increase in water temperature? We also raised the question with them - do you know whether salt or sugar behave the same in alcohol?

Professors Christensen and Johnson did not let this curiosity go to waste. The students were encouraged to experiment, and a complete report of their interesting results was enclosed with the letter from which we quoted above. This seems to us an example of excellent teaching, and is just the kind of activity we hoped PSNS would stimulate.

We have received thoughtful letters from many who are teaching the course. One came recently from another teacher in the curriculum project of the Institute for Services to Education, Professor Melvin O. Smith. He writes, the Thirteen Colleges Curriculum Program ''is directed at improving the academic growth and attitudes of students in 13 predominantly Negro colleges . . . I have read your recent PSNS Newsletter and I am submitting the enclosed statement for publication in your next issue.'' Professor Melvin's statement is reprinted in its entirety below. It seems to us a fitting way to end our last Newsletter.

Norfolk State College is a predominately Negro Liberal Arts Institution located in an urban setting in one of Virginia's larger cities. Although the college offers a diversified academic program, a very large segment of its student population is the non-science major. Many of these students are fearful of science courses and fail to see the relevance of being subjected to our traditional physical science courses.

PSNS materials are being used in an experimental course which is a part of a curriculum development project. The aim of the project is not only to improve the academic achievement of the students but to produce students with a greater appreciation of science and the way of the scientist. The curriculum development project is being sponsored by the Institute for Services to Education and experimental science courses are utilizing PSNS materials which are in progress at thirteen additional institutions.

Student Responses:

Student interest in the course is relatively high. They find that the materials are meaningful and, for the most part, things that they have seen before. (Some of the experiments can be done at home with household equipment). Student participation has increased tremendously. They look forward to classroom experiments and demonstrations. Because of the interest and participation, the students seemingly are losing some of the fear that is normally associated with physical science courses on campus. At mid-term, the advisory grades were much better than grades that I have been forced to submit while teaching with traditional materials.

Evaluation:

The PSNS materials seemingly are moving the students forward, however, it would be a bias statement to say that PSNS is THE answer to the problem of the non-science majors at Norfolk State College. The students are progressing relatively well, but it must be noted that the PSNS materials are supplemented by many other materials and techniques. It is safe to say, however, that the PSNS materials serve as a strong nucleus around which our course revolves.

Reports from the other participating colleges seemingly reflect the same finding and observations that I have made at Norfolk State College.

AN APPROACH TO PHYSICAL SCIENCE

March 1, 1967

ANNOUNCING THE RELEASE OF MATERIALS PRODUCED BY THE PSNS PROJECT FOR A COLLEGE COURSE IN PHYSICAL SCIENCE FOR NONSCIENCE STUDENTS

I. The Philosophy of the Approach

A. For whom was the course designed?

Most of the students in the physical science course in many colleges are elementary education majors. They have had very poor preparation in science and mathematics and are afraid of these subjects. It was with these students in mind that the PSNS materials were designed. However no mention is made of teaching methods and the course is suitable as a fundamental background course for any nonscience student. It should not be taken by students with an aptitude for science who have done well in good courses in physics or chemistry.

B. What is important in a course for such students?

A survey course cannot cover everything. The student tries to remember as much as possible and panics on examinations when he forgets what he memorized. If he becomes a teacher he feels insecure because he knows the student can ask questions which he cannot answer. Such an attitude is remote from the spirit of science.

Central to science is the enjoyment of observing the universe and wondering about it, postulating models consistent with our observations and testing them in new situations. This is what is important in a course for such students. If the student can become involved in this process, then he is sharing with professional scientists an understanding of how we know what we know. If he becomes a teacher he can make rich use of the new teaching kits that depend on the exploratory approach, rather than being afraid to use them because he does not "know the answers."

To give the student time to observe and wonder and explore on his own, the content of the course must be drastically limited. He cannot participate realistically in scientific inquiry when he is rushed along at a pace not suited to his capacities. The choice of a subject area is somewhat arbitrary. Seeking an area shared by physics and chemistry and rich in experimental

material related to the tangible world around us, we chose to focus attention on solids, how they behave under a variety of conditions, what models we can think up which are consistent with our experimental results and what means we use to test the models we have devised.

C. What pedagogical techniques characterize the course?

The students for whom this course was designed are likely to start out with a prejudice against it. At best, they are probably disinterested in the subject and apprehensive about their inability to handle it. Unless we make some progress in overcoming these attitudes we can teach them little.

Scientists find science fun. Why? In part because they observe something that puzzles them and proceed to learn more about it because they need to know in order to make for themselves a satisfactory model consistent with their observations. They can't always succeed in this and may have to put the problem on the shelf and come back to it later when further work has enriched their understanding of it.

Commonly we teach students what we know they are going to need and then show them a demonstration of what they have learned. This backward procedure takes away the motivation that the scientist thrives on. The underlined words in the previous paragraph have served as key words for the pedagogical techniques used in the PSNS course. These are honest techniques, consistent with real-life scientific investigation. It has been our experience, in trials in eight colleges in 1965-66 and twenty-three colleges in 1966-67, that the students respond to the sincerity of this approach and are motivated by having subject matter withheld until they need to know it.

D. The experimental approach is central to the course.

Experiment is central to physical science. It must be central to any course in physical science. The experiments in the PSNS course are written as part of the text. Some of them can be performed at home or in a dormitory room. A few can be performed on the arm of the chair in the lecture room; we call these "chair-arm experiments." We have tried to keep all of the equipment for experiments simple so that the science is not obscured by the apparatus. Where possible we have chosen materials commonly available, such as rubber bands, paper fasteners and flashlight batteries. With very few exceptions the experiments can be performed in a room where the only facilities are water, a large table and a standard electric outlet.

II. The Materials

A. The text

The course is a full-year course, preferably to be taught in three classroom hours and two laboratory hours, but readily adaptable to two classroom hours and two laboratory hours; less readily to less time. The text was cooperatively produced by the members of the PSNS staff, all of whom are college teachers of physics or chemistry. The first draft, including experiments as

an integral part of the 5-volume, 18-chapter text, was written at Rensselaer Polytechnic Institute during the summer of 1965. It was tried by eight colleges (see Section V) during the academic year 1965-66. In the light of the feedback from the eight instructors during one day at midyear and one week in June, the text was revised in the summer of 1966 and a new edition, comprising 3 volumes of 17 chapters, was tried by twenty-three colleges (see Section V) in 1966-67. The two-day, February, 1967, feedback session attended by the 1966-67 instructors has resulted in minor revisions of the first nine chapters (Volume 1 of the two-volume text). The complete text will be commercially published for use during the academic year 1967-68. Very slight revision of this text is anticipated prior to the "final" edition of the text. The 1967-68 text will probably cost the student about ten dollars.

The titles of chapters in the 1966-67 edition are:

1. You and physical science
2. When, where and how much?
3. A look at light
4. Interference of light
5. Crystals in and out of the laboratory
6. What happened in 1912
7. Matter: a closer look at differences
8. Matter in motion
9. Energy and the kinetic theory
10. Forces inside matter
11. Electric charges in motion
12. Models of atoms
13. Ions
14. The nature of an ionic crystal
15. Bonding in molecules
16. Relationships between structure and behavior
17. What it is all about

Numbered questions closely related to specific text topics occur throughout the text and questions of a more general sort occur at the end of each chapter. Each chapter is supplied with a specific page-referenced, annotated list of further reading relevant to the subject matter of the chapter and appropriate in level for the students in this course, not a broadside bibliography.

B. The supplementary chapters

The most important ingredient in the success of any course is the enthusiasm of the instructor for teaching it. The directors of the PSNS Project felt that an instructor would be more enthusiastic about a course for which he had had some share of creative responsibility. To this end, the intention is that the material in the seventeen chapters listed above shall be inadequate to fill the time in a full year's course. The instructor may select at will additional "Supplementary Chapters" according to his own interests, but should not add so much material that it destroys the comfortable pace of the course for the students for whom it was designed.

Supplementary chapters expected to be available for trial during 1967-68 are:

Some properties of acids and bases (printed August, 1966)
Magnetism
Equilibrium
Avogadro's number
The properties of the nucleus
Orbits in space

Additional supplementary chapters that will probably be available for 1968-69 are:

The solid matter of the Earth
Geometrical optics
Biological molecules

The supplementary chapters will probably be bound individually, paper covered, available separately at a cost to the student of less than a dollar each.

C. The resource book

The teaching approach of the PSNS course differs from that of most currently taught physical science courses for nonscience students. It has been our experience that most teachers find it a more difficult approach but richly rewarding when they have become accustomed to it.

The trial teachers during the first two years have either been members of the PSNS staff or have attended a two-week briefing session at Rensselaer Polytechnic Institute. During the summer of 1967 a teacher training institute will be held at Rensselaer Polytechnic Institute which will be attended by some of those planning to teach the course in 1967-68. (See Section III B, below). However, the directors of the project know that they cannot hope to be in personal contact with all future instructors of the course and must rely upon a resource book to carry to future instructors the concepts on which the course is based. In addition to carrying the philosophy of the course, such a book will include answers to all answerable text questions and discussion of thought-provoking questions which do not have specific answers; additional questions and answers suitable for homework and quizzes will be included. The book will also contain background enrichment helpful in lecture preparation and practical advice concerning the experiments.

The origin of the book was a series of letters to the instructors in 1965-66. In 1966-67 it became a loose-leaf notebook incorporating all of the above features, but not in complete form for every chapter. Intensive work on this book during the summer of 1967 will make it a useful volume for the instructor of the 1967-68 course. The PSNS Resource Book will be free of charge to each instructor in 1967-68 and throughout the period of its development.

D. The equipment

The equipment is simple, in keeping with the philosophy of the course. During 1965-66 the equipment supply was handled by Professor Earl Carlyon of the PSNS staff, working individually with an apparatus supplier. During 1966-67 all supplying and shipping was handled by Damon Educational, Inc., with Professor Carlyon providing liaison with the project. Because the experiments are an integral part of the course, close contact between the writers and the equipment supplier has been important. Although some items, such as large rubber bands, paper cups and glass tubing are readily purchased in most locations, we have found that busy instructors appreciate the convenience of having all the equipment for one experiment available in a package.

It is anticipated that the total annual equipment cost per student will not exceed thirty dollars. The more costly items are re-usable so the cost would drop appreciably the second year. Some items, such as test tubes and alcohol burners, may already be available at the college and need not be purchased.

III. How to Proceed if You are Interested.

A. How to get newsletters and samples of the text

At the end of this section is a blank for you to cut out, fill out and mail to the Director, Dr. Lewis G. Bassett of Rensselaer Polytechnic Institute, for samples of the PSNS Project newsletters and the 1966-67 text, including those supplementary chapters that are available.

B. The teacher training institute

During the summer of 1967, an eight-week summer institute in physical science will be held at Rensselaer Polytechnic Institute, with Professor Arnold A. Strassenburg of Stony Brook and Professor Stanley C. Bunce of R.P.I. as co-directors. Professor Strassenburg will act as chief instructor, assisted by Professor Bunce of the Chemistry Department and Professor Wilfred E. Campbell of the Materials Engineering Department at R.P.I., and Professor Robert L. Sells, Chairman of the Department of Physics at the State University College at Geneseo, New York.

Attendance at this institute has not been limited to those who plan to teach the PSNS course the following year, but many of those attending the institute will be PSNS instructors. Special classes will be given in chemistry for those whose background is stronger in physics, and in physics for those whose background is stronger in chemistry. It is hoped that this will facilitate the teaching of an integrated physical science course by a single instructor, a result desirable for any course in physical science.

We plan to hold a similar institute during the summer of 1968. Those interested in participation in the 1968 institute should fill out the appropriate blank at the end of this section. Attendance at the institute is not a prerequisite for using the PSNS course.

C. How to obtain materials for teaching the course

The publisher for subsequent editions of the text has not yet been chosen, but this decision will be made soon. He will be the supplier of a third preliminary edition to be used during the next two academic years and a final edition for subsequent use.

Damon Educational, Incorporated (240 Highland Avenue, Needham Heights, Mass. 02194), who have supplied the PSNS equipment during the early years of course trials will continue to be a source of equipment. Other apparatus companies may also be able to supply suitable equipment.

We will need to provide the publisher and the equipment supplier with an estimate of the number of students who will need texts and equipment in the fall of 1967 and the fall of 1968. At the end of this section is a blank which you should fill out if you anticipate teaching the PSNS course in either of the two coming academic years. You will not be bound by your statements on this blank, but the project directors urge you to fill it out and send it in if you think you will probably use the PSNS materials. The purpose of this is to serve you better since the text publishers and equipment suppliers need to know well ahead of time approximately the size of the orders they will be required to fill. This does not constitute an an order for texts or equipment but does insure that they will be availabe for your use.

Although no formal permission is required for you to use the course, we recommend that you keep in close touch with the directors of the project who may be able to give you valuable assistance. We will welcome your comments on experiences in teaching the course. Such feedback provides the basis for continuing improvement in the course materials.

REQUEST FOR SAMPLE MATERIALS

(Cut on broken line, fill out and mail to Professor L. G. Bassett, Department of Chemistry, Walker Laboratory, R.P.I., Troy, New York 12181)

Please send present and future PSNS newsletters, 1966-67 text and any available supplementary chapters to

Name: ______________________________

(Include title you prefer: Mr., Dr., Prof., Sister, Miss, etc.)

College Address: ______________________________
(Include Department)
(or other institution)

____

____

____
(Zip Code No.)

EXPRESSION OF INTEREST IN PARTICIPATION IN THE TEACHER TRAINING INSTITUTE AT RENSSELAER POLYTECHNIC INSTITUTE DURING THE SUMMER OF 1968.

(Cut on broken line, fill out and mail before May 15, 1967 to

Professor A. A. Strassenburg
State University of New York at Stony Brook
Stony Brook, New York)

I may wish to participate in the 1968 Teacher Training Institute at Rensselaer Polytechnic Institute and would like to receive additional information when it becomes available. I am / am not now teaching a course in Physical Science.

My most advanced degree is ______________________________

My major subject was ______________________________

Brief record of teaching experience: ____________________

____

____

____

____

Name: ______________________________

College Address: ______________________________

____

____

(Zip Code No.)

NOTICE OF INTENTION TO TEACH THE PSNS COURSE

(Cut on broken line, fill out and mail to

Professor A. A. Strassenburg

State University of New York at Stony Brook,

Stony Brook, New York)

I expect to use the PSNS course during the academic year
1967-68____ (Please indicate.)

1968-69____

Estimated number of students in course each year:________________

Estimated average number in a lab section:________________

How many, if any, lab sections will be taught simultaneously?______

(This will require more equipment than successive labs where

equipment is re-usable.)

Name of college:________________________

Type of college:________________________
(Community, liberal arts, private, state, junior, etc.)

Name: ________________________________
(Include preferred title: Mr., Dr., Prof., Miss, Sister, etc.)

Address: ________________________________

____

____

____
(Zip Code No.)

IV. The Rersonnel of the PSNS Project

A. Members of the Advisory Board

Lewis G. Bassett, Rensselaer Polytechnic Institute (1964-68)
Walter E. Eppenstein, Rensselaer Polytechnic Institute (1967-68)
Donald F. Holcomb, Cornell University (1966-68)
Alan N. Holden, Bell Telephone Laboratories (1964-68)
Frank R. Kille, New York State Department of Education (1964-68)
Arthur H. Livermore, American Association for the Advancement of Science (1964-68)
Charles C. Price, University of Pennsylvania (1964-68)
Robert Resnick, Rensselaer Polytechnic Institute (1964-68)
Robert L. Sells, State University of New York College at Geneseo (1964-68)
Arnold A. Strassenburg, State University of New York at Stony Brook and American Institute of Physics (1966-68) Chairman of the Board, 1966-68.
James H. Werntz, University of Minnesota (1966-68)
Elizabeth A. Wood, Bell Telephone Laboratories (1964-68) Chairman of the Board, 1964-66.

B. PSNS Staff (Dates refer to summer writing conferences)

Director: L. G. Bassett, Rensselaer Polytechnic Institute (1965,66)
Associate Directors: R. L. Sells, State University of New York., College at Geneseo (1965,66)
A. A. Strassenburg, State University of New York at Stony Brook (1966)
E. A. Wood, Bell Telephone Laboratories (1965,66)

J. J. Banewicz, Southern Methodist University, Dallas, Texas (1965)
S. C. Bunce, Rensselaer Polytechnic Institute, Troy, New York (1965,66)
W. E. Campbell, Rensselaer Polytechnic Institute, Troy, New York (1965)
E. L. Carlyon, State University of New York at Geneseo, Geneseo, New York (1965,66)
M. T. Clark, Agnes Scott College, Decatur, Georgia (1966)
T. H. Diehl, Miami University, Oxford, Ohio (1965)
Sister M. de la Salle, O.S.F., Alverno College, Milwaukee, Wisconsin (1966)
W. E. Eppenstein, Rensselaer Polytechnic Institute, Troy, New York (1965)
D. F. Holcomb, Cornell University, Ithaca, New York (1966)
S. J. Inglis, Chabot College, Hayward, California (1966)
J. L. Katz, Rensselaer Polytechnic Institute, Troy, New York (1965)
H. M. Landis, Wheaton College, Norton, Massachusetts (1965,66)
S. H. Lee, Texas Technological University, Lubbock, Texas (1965)
W. J. McConnell, Webster College, Webster Groves, Missouri (1966)
H. F. Meiners, Rensselaer Polytechnic Institute, Troy, New York (1965)
E. J. Montague, Ball State University, Muncie, Indiana (1965)
L. V. Racster, Rensselaer Polytechnic Institute, Troy, New York (1965,66)
A. J. Read, State University of New York at Oneonta, Oneonta, New York (1965)
R. Resnick, Rensselaer Polytechnic Institute, Troy, New York (1965,66)
F. J. Reynolds, West Chester State College, West Chester, Pennsylvania (1965)

R. K. Rickert, West Chester State College, West Chester, Pennsylvania (1965,66)
R. S. Sakurai, Western College for Women, Oxford, Ohio (1965,66)
J. Schneider, St. Francis College, Brooklyn, New York (1966)
L. Smith, Russell Sage College, Troy, New York (1965,66)
A. A. Strassenburg, State University of New York at Stony Brook and American Institute of Physics (1966)
P. Westmeyer, Florida State University, Tallahassee, Florida (1965,66)
S. E. Whitcomb, Earlham College, Richmond, Indiana (1966)
E. Wright, Montana State College Bozeman, Montana (1965)
E. A. Wood, Bell Telephone Laboratories, Murray Hill, New Jersey (1965,66)

V. The Trial Colleges and Instructors (Numbers in parentheses are approximate numbers of students)

A. <u>During the academic year 1965-66</u>

Ball State University, Muncie, Indiana; E. J. Montague (880)
Earlham College, Richmond, Indiana; S.E. Whitcomb (20)
Miami University, Oxford, Ohio; T. H. Diehl (20)
Montana State College, Bozeman, Montana; N. Kutzman (30)
State University of New York College at Geneseo, New York; E. L. Carlyon (150)
Webster College, Webster Groves, Missouri; W. J. McConnell (30)
West Chester State College, West Chester, Pennsylvania; R. K. Rickert (40)
Western College for Women, Oxford, Ohio; R. S. Sakurai (10)

B. <u>During the academic year 1966-67</u>

Alverno College, Milwaukee, Wisconsin; Sister B. Handrup (100)
Arkansas State Teachers College, Conway, Arkansas; D. L. Prince (59)
Bloomsburg State College, Bloomsburg, Pennsylvania; N. E. White (100)
Catholic Diocese of Brooklyn, New York; Brother J. Donohue, Brother Gratian Ohmann, Sister J. Daniel (110)*
College of Notre Dame of Maryland, Baltimore, Maryland; Sister M. Avila (55)
College of St. Benedict, St. Joseph, Minnesota; Sister Paschal (50)
Earlham College, Richmond, Indiana; S. E. Whitcomb (25)
Fairleigh Dickinson University, Madison, New Jersey; C. Grove (40)
Florida A and M, Tallahassee, Florida; Mrs. I. E. Glover (10)
Green Mountain College, Poultney, Vermont; L. W. Boothby (50)
Harford Junior College, Bel Air, Maryland; J. D'Amario (70)
Mansfield State College, Mansfield, Pennsylvania; R. H. Mason (150)
Meramec Community College, Kirkwood, Missouri; J. Walka (100)
Miami University, Oxford, Ohio; T. H. Diehl (15)*
Montana State College, Bozeman, Montana; N. Kutzman (65)
Nassau Community College, Garden City, New York; S. Aronson (35)
Newark State College, Union, New Jersey; A. A. Silano, J. Wagner (100)
State University College at Geneseo, Geneseo, New York; E. L. Carlyon, R. L. Sells (150)

The Colorado College, Colorado Springs, Colorado; M. K. Snyder (30)
University of Southwestern Louisiana, Lafayette, Louisiana; Z. L. Loflin (50)
University of Texas, Austin, Texas; D. Gavenda, K. Anderson (95)
Webster College, Webster Groves, Missouri; W. J. McConnell (30)
Western College for Women, Oxford, Ohio; R. Sakurai (16)

* In-service course

APPENDIX E-4

Five Journal Articles

REMOVED PRIOR TO BEING SHIPPED TO EDRS FOR
FILMING DUE TO COPYRIGHT RESTRICTIONS.

APPENDIX E-5

A Feedback Report Form

College. . . . . We have just finished Chapter.......

Instructor. . . . . Date. . . . .

FEEDBACK FORM

Experiments done in lecture room

Chair-arm:

Demonstration:

Experiments done in laboratory:

Experiments done at home:

Questions used as homework:

Did some question (whether used as homework or not) stimulate interesting class discussion? Which?

Please attach copies of other homework assignments or questions that you found useful.

Are there parts of this chapter that you think should be deleted from the text?

If so, state section numbers or indicate parts of sections or pages.

Are there places in the text where you think fuller explanation (spelling it out more carefully, taking it more slowly or giving more examples) would be helpful?
If so, where?

Are there parts where you think the explanation is too full?
If so, where?

Are there related matters that you think should be added to this text, remembering that we are trying to keep it from getting too long?
If so, what?

The back of this sheet is to be used for further comment. In particular please make a brief note of any especially favorable or especially unfavorable reactions which you or the students had to anything in this chapter.

Were there places where a fuller amplification in the Reference Book would have been useful to you? Where?

Evaluation of PSNS: Chapter 1-7

I. Comment on the style of writing: Are there parts you like; don't like: parts that seem too difficult or sophisticated: parts that seem too childish or simple: Be specific in pointing out these portions.

II. Comment on how logical you think the development is:

III. Comment on the approach: that is do you feel that the basic principles should be just stated or described rather than trying to develop them through experiment.

IV. Comment on the independent study experiments (those you did outside of class so that you could go at your own rate of speed.)

V. Go through the text and comment on the relevance of each experiment or activity. Did you feel that some experiments seemed trivial at the time they were done, but later fit into the total picture ----if so, which ones.

VI. Please comment on your reaction to the course. Be rather specific.

APPENDIX E-6

The Welch Evaluation Reports

A Summative Evaluation of the PSNS Course. Part I: Design and Implementation

by

Wayne W. Welch, University of Minnesota

This report is the first in a series of articles describing an evaluation of the course called Physical Science for Nonscience Students (PSNS). The course is one of several to evolve during the decade of the 60's under the sponsorship of the National Science Foundation. It is unique, however in two respects; first because it is directed toward the nonscience major at the college level, and secondly, because it contracted to an outside agency for a thorough evaluation of its effectiveness. It is this latter fact that is the main concern in this paper.

Because evaluation of national projects is seldom conducted[1] it seems appropriate to record in the literature the purposes and procedures of the PSNS evaluation. In the review article cited above only 19 of 65 projects have information available regarding the achievement of their goals. It is the purpose of this paper to present in detail the rationale for the PSNS evaluation, and to describe the chosen strategy and method of implementation. In a subsequent paper, the results of the evaluation will be presented.

Design

When conducting an evaluation study, three distinct questions need to be considered. Answers to these questions give direction and guidance to the evaluator. First, why is the evaluation being conducted? Second, what is being evaluated? And finally, how should the evaluation proceed? Each of these questions is discussed briefly in terms of the PSNS evaluation problem.

Why evaluate?

Evaluation is the gathering of information for the purpose of making more effective decisions. These decisions usually serve the functions of course improvement or user information and are called formative and summative evaluation respectively. A related reason for evaluation is apparent to anyone who has conducted a study and is something I choose to call supportive evaluation. It has very little to do with decision making, but seems to grow out of the needs of men for positive reinforcement of the efforts they have put forth. While supportive evaluation is seldom, if ever, formalized, one cannot help but notice its presence among those contracting for evaluation services.

The need for administrative decision making is exerting strong pressure on all funded projects for another kind of evaluation that departs from course improvement, user information, or reinforcement. A useful label is administrative evaluation. It focuses on gathering information to aid those facing funding decisions; for example, state departments, USOE title officers, and local school boards. These people need to make decisions about which proposals to fund and which projects to continue funding. They are requiring more information to assist them in this task. Although related to the needs of project directors to gather information to insure the development of a quality product, the external funding decisions require a different focus of evaluation activity. Perhaps advances in the state of the art of evaluation will be made when techniques are developed for gathering the same data that satisfies all evaluation purposes: formative, summative, supportive, and administrative.

Where does the PSNS need for evaluation fit into this classification? It appears that a final product evaluation (summative) is being done for three prospective audiences; the consumer, the funding agency, and the developers.

Each has a unique interest in the results. Fortunately, each need can be satisfied in the same way. That is by answering the question, "Have the objectives of the course been achieved?" If the answer is yes, the consumer has additional information for his adoption decisions, the developer has reinforcement for his long years of involvement, and the funding agency has accountability for its investment. The answer to "Why evaluate the PSNS course?" is primarily for summative reasons, with both supportive and administrative overtones. What is to be evaluated and a proposed strategy for conducting the evaluation follows in the next two sections.

What is being evaluated?

The PSNS course grew out of a conference on the subject of college courses in physical science for nonscience students held by the Commission on College Physics with the cooperation of the Advisory Council on College Chemistry. It was funded by the National Science Foundation initially in 1965 with the goal of developing a suitable one-year course for the nonscience student. A commercial edition of the materials was available during 1969 and the evaluation of the course was conducted during the 1969-70 academic year.

The main objectives of the course are to improve students' attitude toward science and to give them an understanding of the scientists' approach. Using a great deal of laboratory work the course concentrates on the topic of the nature of solid matter -- what it is like and how we find out about it. Perhaps its greatest departure from the more conventional physical science course is this focus in depth on a single topic rather than being a survey course. The course materials consist of a textbook containing both laboratory experiments and descriptive material, laboratory apparatus, teacher's resource book, and five supplementary chapters. Summer institutes and workshops have been held by the National Science Foundation and the publisher, John Wiley and Sons, to acquaint college teachers with the course materials and philosophy.

A more detailed description of the PSNS Project is found in the September, 1966 issue of the American Journal of Physics, entitled "PSNS Project at RPI" or in the Commission on College Physics Newsletter #17 (October, 1968).

How to evaluate.

As one searches the curriculum evaluation literature, or is involved in different evaluation studies, a number of approaches to evaluation are available. These might be called (1) time series experiments[2], (2) control group designs, (3) objective achievement (Tyler model), and (4) accreditation studies. An example of each is given to illustrate the approach. A time series experiment occurs when a school system introduces a new scheduling pattern, but before implementing it gathers achievement scores and graduate questionnaire data. The new program is introduced and two years later the same data is again gathered and compared with the baseline data. Changes in outcomes give clues to the impact of the new schedule.

The second pattern follows traditional research design methodology and is illustrated by the national random selection with random assignment of physics teachers to experimental and control groups of the Harvard Project Physics evaluation[3].

The AAAS evaluation plan specified behavioral objectives and sought to determine if students were achieving these objectives. This is the procedure of the Tylerian approach. Extending this pattern to a school system could be accomplished by stating a series of behavioral objectives for the school and then determining the extent to which these objectives are achieved. An example from a current evaluation study[4] for a local school system sets as a specific objective, "80% of the students will respond positively to the statement, 'I prefer flexible modular scheduling to conventional class scheduling.'" Data is then obtained to determine if this objective is achieved.

Finally, the fourth design is typified by school accrediting agencies (e.g. North Central Association) where local staff members and outside consultants place value judgments on the educational opportunities available in a given school system or program.

The strategy chosen for the PSNS course is best characterized as a control group comparison. The primary objectives of the curriculum are identified and the evaluator determines if the experimental program achieves these objectives more effectively than other alternatives. While objective determination does not insist on a comparison group, the existence of possible alternatives (in this case, conventional courses) suggest strongly the need for a comparison. When a course is developed to achieve certain objectives, the responsibility exists to demonstrate not only that the objectives are achieved, but that they are achieved more effectively than in other viable alternatives. Accordingly, a control group design was chosen for the PSNS evaluation. The components of the design are described below.

Testing plan

Although some authors have questioned the feasibility of national curriculum evaluation using randomized groups, the success of the author in the evaluation of Harvard Project Physics[3] provided encouragement to try a similar design for the PSNS evaluation. Schools and teachers were sought who could teach the experimental course (PSNS) and who were also teaching a conventional physical science course. Students were then randomly assigned to either the experimental or control group. Table 1 illustrates this design as presented by Campbell and Stanley.[5]

(Insert Table 1 about here)

Table 1

EVALUATION DESIGN FOR PSNS CURRICULUM

R:	O_1	X	O_2
R:	O_3		O_4

In the figure, O's represent several different tests, given both as pretests and posttests. The X represents the experimental treatment, the PSNS course. Once this research design was chosen, it became extremely important to find colleges and professors willing and able to cooperate within the rather strict limitations imposed by the design.

Sample selection

The names of all potential teachers using the PSNS course in the fall of 1969 were obtained from the text publisher, John Wiley and Sons, Inc. They had mailed nearly 1500 promotional packages to all potential physical science professors in the spring of 1969. In April, a request-for-comment letter was sent to each of these professors asking them their opinion of the course, and to return a questionnaire indicating if they were going to teach it during 1969-70. On May 1, all replies received to that date (n=275) were culled and a total of 59 professors indicated they were going to be teaching PSNS.

On May 5, a description of the evaluation and a letter of invitation were mailed to these 59 prospective cooperating teachers. Those professors and their students able to abide by the rather restricting conditions of the experiment became the sample of this study. A total of 48 teachers replied to the invitation and 13 indicated they were able to cooperate according to the specifications. Later one had to withdraw because budget problems did not allow him to introduce the new course. This left a total of 12 professors that comprised the sample of the evaluation study. The 12 instructors came from 10 different colleges in eight states, representing a diversity of college environments.

Several comments are in order here for those researchers faced with similar problems. May 1 was necessarily chosen as the cut-off deadline for returns to the publisher because of the need to reach professors before the school year closed.

However, a population of 59 at that point was considered adequate since we could not involve more than 20 due to financial limitations. Because we would be making demands on the testing time of the professor and because they would be teaching both PSNS and a conventional physical science course, a modest honorarium of $75.00 was offered to the instructors. In retrospect, this was not nearly enough for the requests we made. However, we received wonderful cooperation, and the success of this evaluation study is largely due to the cooperation of these 12 professors and their colleges.

Briefly, each professor agreed to teach at least one section of PSNS and another physical science course, to randomly assign their students to either the experimental or control course, and to administer a series of pre and post tests during the year. The results of the sample selection are presented in Table 2.

(Insert Table 2 about here)

Test selection and development

As mentioned earlier, the two main objectives of the PSNS course were to change students' attitude toward science and to develop in them a sense and understanding of the scientist's approach. Considerable thought had gone into enlarging upon these two objectives, a rarity in curriculum development groups. It is important to point out at this time that gains on traditional achievement tests were definitely not an objective of the program. The focus was on student attitude and process understanding. The components of this learning as perceived by the course developers is shown in Table 3.

(Insert Table 3 about here)

Table 2

RESULTS OF SAMPLE SELECTION

School	Estimated PSNS Enrollment	Estimated Control Enrollment	Treatment Duration	Control Text*
A	44	41	Semester	B
B	54	117	Year	C
C	52	54	Semester	A
D	49	44	Semester	B
E	15	30	Semester	A
F	14	25	Year	A
G	30	55	Semester	A
H	24	21	Year	C
I	44	44	Year	C
J	23	35	Semester	C
K	46	49	Semester	A
L	30	60	Semester	B
Total	425	575		

*Text Code

A. Baiser and Krauskopf, "Intro. to Physics and Chemistry"

B. Miles, et al, "College Physical Science"

C. Other (Each school used a different text)

Table 3

Objectives of the PSNS Course

Substantive:

1. To encourage the observation of natural phenomena among college students who are nonscience majors.

2. To encourage curiosity about natural phenomena and to teach nonscience students how to formulate questions about physical situations.

3. To teach nonscience students how to propose models and hypotheses to aid in understanding the behavior of matter and energy.

4. To teach nonscience students how to design simple, controlled experiments to test their hypotheses.

5. To teach nonscience students how to analyze experimental results.

6. To stimulate an awareness of problems of current interest to scientists.

7. To provide for nonscience students a basis for recognizing the limitations of science.

Attitudinal:

1. To convince nonscience students that science is fun.

2. To persuade nonscience students that with effort, every intelligent individual can learn to analyze events in a scientific manner.

3. To convey to nonscience students a sense of the beauty of the natural world and the power of logical analysis.

4. To develop in prospective teachers an appreciation for the use of simple scientific apparatus to illustrate an idea.

5. To generate in each nonscience student a confidence in his own ability to successfully seek answers to questions about the natural world.

Admittedly, translation of these objectives into data is a hazardous task. However, several techniques have evolved in recent years that seem valid to measure these objectives, especially at the group level. Let us consider the process goals first.

Two existing process instruments, the Test on Understanding Science (TOUS)[6] and the Welch Science Process Inventory (SPI)[7] were thought to contain several items measuring the objectives of the PSNS course. These instruments were given to three of the course authors with instructions to select those items where it was thought that a student completing PSNS would definitely possess sufficient process understanding to answer the item correctly. Thus from a potential pool of 60 TOUS items and 135 SPI items, a sample of PSNS process items was selected by three course judges. An item had to be selected by two of the three judges for inclusion in the PSNS Process of Science Measure (POSM). Using this selection criteria, a total of 114 items were chosen, 24 from TOUS and 90 from SPI. These items comprised the measure of the substantive course objectives.

The semantic differential technique was chosen to evaluate achievement of the attitudinal objectives. Again the course authors were presented with a series of semantic differential concepts and scales that had been used in previous science evaluation studies.[8] They were asked to select those items that appeared to measure the objectives considered important in PSNS. For example, in response to the concept SCIENCE, students were asked to rate it on a seven point scale between Fun and Boring. This was considered one way to measure attitudinal objective number one.

Two other testing techniques were chosen by the evaluator to represent instruments not specifically oriented towards the PSNS course. The Physical Science scale of the Academic Interest Measure[9] assesses interest in school subjects and normative data is provided for college students.

This instrument will provide data on the type of student that enrolls in the PSNS course and will be used to determine what changes in interest take place as a result of the course.

A second non-PSNS developed test is the Scientific Attitude Inventory[10] recently developed to measure intellectual and emotional scientific attitudes. The test-retest reliability of this instrument is reported by the authors to be 0.93.

The five testing instruments were combined into two booklets, the Process of Science Measure (POSM) and the Attitude Measure (AM) and mailed to the participating professors for administration during the first two weeks of school. Total testing time for the pretests was two class periods. Biographic information regarding the students was obtained using the front page of the POSM.

A total of 430 PSNS students completed both instruments while 571 students in the control courses took the pretests. Expected attrition in both the experimental and control courses did occur during the year so that fewer numbers completed the posttests. Much of the attrition is due to the one semester science requirement by the colleges. After completing the first half of the course to satisfy the minimum requirement, the student opts not to take the second semester as an elective.

Posttests were mailed in order to be administered during the first week of May, 1970. Many schools begin exams in the middle of May and one always runs the risk of an anti-intellectual feeling that seems to creep into colleges with the coming of spring. A total of 305 PSNS students and 362 control students completed the posttests and were returned by June 20, 1970. The completed test comprised one source of data for the course evaluation. As a check on the operation of the experiment and to meet students and teachers personally, the evaluation director visited seven of the participating schools during the year. Time was spent

discussing the course with students, and visiting classes and laboratories in both experimental and control schools. These visits proved particularly informative on the logistic problems in teaching physical science, provided insights into the difficulties encountered by students and teachers, and served to validate the data obtained by the paper and pencil techniques. The subjective impressions of these visits will comprise part of the final evaluation report.

<u>Results</u>

Currently the data obtained from the design and implementation stage is being processed and will be presented in a subsequent report. Planned analyses include analysis of variance between the experimental and control groups, differing effects of teaching the course for one semester and one year, sex differences, and effect on students of various majors, particularly prospective elementary teachers. The data also provides a basis for a number of research studies and is currently being used by two doctoral candidates. The PSNS evaluation study provides a means by which these students have access to schools that would otherwise be closed to them.

As a guide to others facing similar evaluation problems it seems appropriate to discuss briefly the results of the evaluation strategy and implementation. Several facts emerged from this college curriculum evaluation that are summarized here.

1. Evaluation of a national curriculum project in a dozen colleges and universities using nearly 1000 students is possible due to the fine cooperation received from the cooperating professors.

2. The National Science Foundation is interested and willing to support evaluations of the projects it funds.

3. Cooperating teachers should be paid an honorarium commensurate with the duties they are asked to perform. In retrospect $75.00 is inadequate.

4. College students will cooperate in the evaluation of college programs.

5. Random assignment to experimental and control groups is possible to a limited degree for curriculum evaluation.

6. There is considerable attrition among students enrolled in physical science courses. The decline in the PSNS course was 29%, in the control classes it was 37%. Visits with students and faculty indicated the primary reason is the one semester physical science elective requirement of the schools.

7. The control group pre and posttest design chosen for this evaluation supplemented by on-site visitations seemed adequate to obtain the desired information.

Based on this summary, it would appear that apart from any differences to be found in the results, the chosen strategy and method of implementation offers a viable model to others contemplating curriculum evaluation studies.

References

1. Welch, Wayne W., Curriculum Evaluation. Review of Educational Research 39:429-443; 1969.

2. Campbell, Donald T. and Stanley, Julian C. Experimental and Quasi-Experimental Designs for Research on Teaching, Handbook of Research on Teaching (edited by N. L. Gage), Chicago: Rand McNally, 1963, pp. 171-246.

3. Welch, Wayne W.; Walbert, Herbert J.; and Ahlgren, Andrew. The Selection of a National Random Sample of Teachers for Experimental Curriculum Evaluation. School Science and Mathematics 49:210-16; 1969.

4. Welch Wayne W. A Proposal to Evaluate the White Bear Lake Senior High School Program. Twin Cities Educational Research and Development Council. 211 Burton Hall, University of Minnesota, Minneapolis; 1970. (Mimeo)

5. Campbell and Stanley, op. cit. p. 183.

6. Cooley, W. W. and Klopfer, L. E. Test on Understanding Science, Form W. Educational Testing Service, Princeton, New Jersey, 1961.

7. Welch, Wayne W. and Pella, Milton O. The Development of an Instrument for Inventorying Knowledge of the Processes of Science. Journal of Research in Science Teaching 5:64-68; 1967-68.

8. Geis, Fred Jr. The Semantic Differential Technique as a Means of Evaluating Changes in 'Affect'. Unpublished doctor's thesis. Cambridge: Harvard University, 1969.

9. Halpern, G., Scale Properties of the Interest Index. Educational Testing Service, Princeton, New Jersey, 1965.

10. Moore, Richard W. and Sutman, Frank X. The Development, Field Test and Validation of an Inventory of Scientific Attitudes. Journal of Research in Science Teaching Vol. 7, Issue 2, pp. 85-94.

EVALUATION OF THE PSNS COURSE

PART II. RESULTS

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This paper is the second of a two-part series describing the evaluation of the course called Physical Science for Non-Science Students (PSNS). The background and strategy of the evaluation is described elsewhere (Welch, 1970). The purpose of the current paper is to present the findings of this nationwide study.

As a brief review, the reader is reminded that the study involved approximately 1,000 physical science students drawn from 12 colleges in the United States. The students were randomly assigned to an experimental treatment (PSNS), or to a conventional physical science course that served as a control for the evaluation. A series of attitude and cognitive tests were administered to both groups. The results of the study are grouped into four general categories: I. Characteristics of physical science students, II. Impact of the PSNS course on selected variables, III. Effects of duration of treatment, and IV. Impressions from site visits.

I. Who Enrolls in College Physical Science Courses?

The purpose of this section is to present some background characteristics of the students enrolled in college physical science courses. Apart from the intrinsic interest science educators might have in these students,

there is an obligation of the evaluator to describe the subjects of the evaluation study. If some differential treatment effect is detected, it is important for the decision maker to know the group of subjects being affected. Accordingly, the students enrolled in the PSNS course and in the other physical science courses were asked to provide information about themselves as part of the testing battery.

A questionnaire of approximately 15 items was administered as part of a pre-test package. Areas of interest included career plans, previous science training, and current college status. The summary of responses from 1,009 students located in 12 colleges scattered across the country is presented in Tables 1 and 2.

(Insert Table 1 about here)

The large majority of students enrolled in physical science are underclassmen with slightly more women than men taking the course. One of the target groups for the PSNS course was prospective elementary teachers, and it appears that this group does select physical science in fairly large numbers. While business majors top the list, the combined total of general education, elementary and secondary education (39 per cent), exceeds all other areas.

(Insert Table 2 about here)

The number of high school science courses taken by this group of students approximates figures reported for typical high school graduates (Boercker, 1966); that is, nearly all have taken biology, about half have

TABLE 1

BIOGRAPHIC CHARACTERISTICS OF 1,009 STUDENTS ENROLLED IN COLLEGE PHYSICAL SCIENCE

	Number	Per Cent		Number	Per Cent
Sex			Major		
Female	567	56	Elementary Education	201	20
Male	442	44	Business	199	20
			Education	149	15
Year			Humanities	115	11
Freshman	580	58	Fine Arts	73	7
Sophomore	279	28	Social Studies	57	6
Junior	103	10	Secondary Education	45	4
Senior	34	3	Science	27	3
Other	12	1	Law	14	1
			Other	129	13

TABLE 2

PREVIOUS SCIENCE EXPERIENCES OF 1,009 STUDENTS ENROLLED IN COLLEGE PHYSICAL SCIENCE

Course Taken	Number	Per Cent
High School Biology	899	89
High School Chemistry	531	52
High School Physics	210	21
High School Mathematics		
One Year	102	10
Two Years	294	29
Three Years	305	30
Four Years	219	22
Other	56	5
None	33	3
Other College Sciences		
One Course	238	24
Two Courses	57	6
More Than Two	32	3
None	682	68

completed high school chemistry, and approximately one in five has taken physics. In addition, nearly 90 per cent have completed at least two years of high school mathematics.

At the college level, 32 per cent of the physical science students have taken at least one other college science course. The extent of the science and math background of these students was greater than expected, particularly at the high school level. These findings suggest the new course might properly be aimed at the non-science major rather than the non-science student.

Another way to characterize a group of students is to compare them against available normative data on various tests. This was done for the current sample of physical science students. Scores obtained by this group on the Academic Interest Measure and the Science Attitude Inventory were compared with the normative data for these instruments. The results of this comparison are presented in Table 3.

(Insert Table 3 about here)

Examination of Table 3 reveals differences between the physical science group and normative data for a sample of college juniors. The physical science group expressed greater interest in the areas of social sciences, physical sciences, and biology than typical college students. They were less interested in mathematics. Again these results support the statement made earlier. Students enrolled in physical science appear to be interested in science, and to call them non-science students may be a misnomer. Perhaps the clue to their main characteristic is the low interest in mathematics exhibited by these students.

TABLE 3

ACADEMIC INTERESTS OF 1,009 STUDENTS ENROLLED IN COLLEGE PHYSICAL SCIENCE

	Physical Science Group		Norm Group[a]			
	Mean	S.D.	Mean	S.D.	Difference	t Value
Academic Interest Measure						
Social Sciences	22.1	7.7	19.4	9.0	+2.7	+7.9[c]
Physical Sciences	19.1	7.2	18.0	8.5	+2.1	+6.1[c]
Mathematics	15.0	8.9	16.9	8.7	-1.9	-5.0[c]
Biology	20.6	7.7	16.3	8.8	+2.3	+6.8[c]
Science Attitude Inventory	112.2	11.8	106.6[b]	--	+5.6	--

[a]Sample of 1,170 college students. Reported in Halpern, Gerald, "Scale Properties of the Interest Index," Research Bulletin RB65-40, Educational Testing Service, Princeton, New Jersey (Nov. 1965).

[b]Sample of 67 high school biology students.

[c]All t values significant at the $p < .01$ level.

The rather high interest in social science can be explained by the large proportion of the students majoring in the related fields of social studies, education, business, and the humanities.

Unfortunately, the only data available on the rather new Science Attitude Inventory is for tenth grade biology students (Moore and Sutman, 1970), hardly a valid comparison for college freshmen and sophomores. However, the mean score for physical science students is presented for future reference. It can be seen that it is considerably higher than the biology group. T tests were not computed for the difference because standard deviations were not available for the biology group.

II. Course Effects

The second type of result obtained in this evaluation study is a determination of the impact of the PSNS course as measured by various testing instruments. Several tests were selected by the evaluator and the course authors that appeared to measure the two main objectives of changing students' attitudes toward science, and to develop a sense and understanding of the scientists' approach. These instruments are described in some detail in Part I of the evaluation report (Welch, 1970), but are reviewed here briefly.

Attitudes toward science were determined by the Scientific Attitude Inventory, and by ten cluster scores of a semantic differential test. Students were asked to respond to the concepts, Doing Laboratory Experiments, Myself as a Science Teacher, and Science, on a series of bi-polar adjectives. The adjectives were selected on the basis of a priori hypothesized clusters. The existence of these clusters was checked on

the post-test data. Unfortunately, the reliability of the clusters envisioned for the third concept of this study, Science, were too low to be included in the final results and were deleted from the study. Furthermore, no other logical cluster structure was found. However, the hypothesized clusters for the two concepts mentioned earlier did exist and were used as criterion instruments in this study.

The reliabilities for the 14 dependent variables used in this part of the analysis are presented in Table 4. The other tests of the study are the Test on Understanding Science (TOUS), and the Welch Science Process Inventory (SPI).

(Insert Table 4 about here)

The main analysis of this study compares two different treatment effects on the 14 post-test variables listed in Table 4. As mentioned earlier, more than one dependent variable was needed to evaluate the many stated and suspected outcomes of the PSNS course. The appropriate analysis technique in this situation is a multivariate analysis of variance (Cramer and Bock, 1966). Because the variables are correlated in some arbitrary manner, the separate F tests are not independent. No exact probability that at least one of them will exceed some critical level can be calculated. The multivariate F test takes into account the correlations among the 14 variables. However, in the belief that some observers may be interested in individual variables, all univariate F tests are also reported.

The null hypothesis that was tested was that there was no mean difference between the two treatment groups (PSNS versus other physical

TABLE 4

INSTRUMENT RELIABILITY

Test	N_i	r	N_s	Method
Cognitive				
Test on Understanding Science	24	.61	628	K-R#20
Science Process Inventory	90	.85	628	K-R#20
Affective				
Science Attitude Inventory	60	.93	Manual	Test-Retest
Academic Interest Measure Physical Science	16	.93	Manual	K-R#21
Me Teaching Science				
Fun	3	.84	657	Stepped-up $\bar{r}_{ii}$
Useful	3	.84	657	Stepped-up $\bar{r}_{ii}$
Interesting	3	.84	657	Stepped-up $\bar{r}_{ii}$
Safe	3	.68	657	Stepped-up $\bar{r}_{ii}$
Easy	3	73	657	Stepped-up $\bar{r}_{ii}$
Doing Experiments				
Fun	3	.82	657	Stepped-up $\bar{r}_{ii}$
Useful	3	.59	657	Stepped-up $\bar{r}_{ii}$
Interesting	3	.49	657	Stepped-up $\bar{r}_{ii}$
Safe	3	.54	657	Stepped-up $\bar{r}_{ii}$
Easy	3	.52	657	Stepped-up $\bar{r}_{ii}$

N_i - Number of items.

N_s - Number of subjects used to compute r.

science courses) on all 14 variables simultaneously. The means and standard deviations of the post-test variables are presented in Table 5.

(Insert Table 5 about here)

An F ratio was computed for the multivariate test of the equality of the mean vectors. If this F value exceeds the selected .05 level of probability, an overall difference in treatment effects is indicated. Justification then exists for examining the univariate F tests to determine the direction and relative size of the course effects on each of the independent variables. Here again, the level of significance was set at the .05 level. The multivariate and univariate tests of course effects are shown in Table 6.

(Insert Table 6 about here)

Examination of Table 6 reveals the existence of an overall treatment effect on the 14 variables. The indicated p level is 6.4×10^{-6}. Thus justification is provided for rejecting the null hypothesis of the equality of the mean vectors. Examination of the univariate F's reveals the character of the course differences. Significant differences exist on six of the 12 attitudinal measures of the course effects. Although differences on the two process variables favor the PSNS course, these differences failed to reach the chosen significance levels. Thus it appears reasonable to conclude that the PSNS course is successful in its stated goal to change students' attitudes toward science, but not successful in providing students with a greater understanding of the processes of science.

TABLE 5

TABLE OF POST-TEST MEANS AND STANDARD DEVIATIONS FOR TWO PHYSICAL SCIENCE TREATMENTS

Variable	PSNS Mean	PSNS S.D.	Other Mean	Other S.D.	PSNS-Other
Test on Understanding Science	11.09	3.33	10.72	3.83	+ .37
Science Process Inventory	70.73	7.84	70.00	9.40	+ .73
Academic Interest Measure Physical Science	34.43	7.52	32.89	7.82	+1.54
Science Attitude Inventory	112.3	11.7	110.3	13.6	+2.0
Doing Laboratory Experiments					
Fun	4.24	1.18	4.31	1.24	- .07
Useful	5.87	.80	5.89	.97	- .02
Interesting	3.66	.67	3.60	.65	+ .06
Safe	3.80	.73	3.95	.79	- .15
Easy	4.41	.91	4.38	.98	+ .03
Me Teaching Science					
Fun	4.42	1.22	4.25	1.30	+ .17
Useful	5.98	1.13	5.90	1.34	+ .08
Interesting	4.80	1.35	4.67	1.47	+ .13
Safe	4.10	1.00	3.94	1.12	+ .16
Easy	3.23	1.07	2.99	1.10	+ .24

N

PSNS - 301
Other - 356

TABLE 6

MULTIVARIATE AND UNIVARIATE F TESTS
PSNS VERSUS OTHER

Multivariate F = 1.682 $p < .001$

Variable	Univariate F Tests F	p Value
Test on Understanding Science	1.64	.20
Science Process Inventory	1.09	.30
Academic Interest Measure		
Physical Science	6.57*	.01
Science Attitude Inventory	3.99*	.05
Doing Laboratory Experiments		
Fun	<1	.44
Useful	<1	.81
Interesting	1.21	.27
Safe	6.07*	.01
Easy	<1	.78
Me Teaching Science		
Fun	2.77*	.09
Useful	<1	.44
Interesting	1.27	.26
Safe	3.74*	.05
Easy	7.78*	.005

*$p < .10$ d.f. = 1,655

When compared to other physical science courses, PSNS students indicated greater interest in science (AIM), and had more positive attitudes toward science (SAI). They also perceived themselves when teaching science to be higher on the clusters labeled Fun, Safe, and Easy.

The one negative attitude effect was on the cluster, DOING LABORATORY EXPERIMENTS, Safe. PSNS students rated their doing of laboratory experiments less safe than the more conventional physical science courses. One is prompted to suggest that the great diversity of experiments provided in the PSNS course offers greater chances for hazards, and the response reflects this situation. However, this remark is little more than speculation at this time.

III. Treatment Duration Effects

A question frequently asked the PSNS course developers was "Can the PSNS course be taught in one semester rather than in one year as intended?" This part of the evaluation analysis provides some data to help answer that question. It turned out that approximately half of the colleges participating in the study were offering the PSNS course for the academic year, while the other half taught it in one semester. A similar situation existed in the control classes. Although the reasons for the difference were unrelated to the purposes of the course, e.g., only a one semester requirement, conflicts with other classes, and the like, a comparison was made of the effects of taking the course for one semester rather than for one year.

The variables selected for this part of the study included two process tests; the Test on Understanding Science (TOUS) and the Welch Science

Process Inventory (SPI), and two attitude tests; the Academic Interest Measure and the Science Attitude Inventory. A two-way multivariate analysis of variance was conducted testing the effects of course, duration of treatment, and their possible interaction. Because of the correlation among the dependent variables, a significant multivariate F test provides justification for examining the univariate F's in detail. Again, the analysis was done on the post-test scores. Students were used as the unit of analysis because of the hypothesized interaction of students with the course materials rather than with the teachers.

Cell means and standard deviations for the two-way analysis are presented in Table 7.

(Insert Table 7 about here)

The multivariate and univariate tests of the significance of the effects are shown in Table 8.

(Insert Table 8 about here)

Here we see the strong impact of the duration effect, that is, the one year treatment was more successful than a one semester treatment. Although the finding is consistent with our logic, caution must be urged in the interpretation of these results. Even though there is a significant duration effect on all four variables, the source of this variation may be due in part to the dropping out of the poorer students after completing the one semester requirement in physical science. No control was exercised over those students selecting the year versus the semester

TABLE 7

MEANS AND STANDARD DEVIATIONS
POST-TESTS

Variable	PSNS Semester Mean	PSNS Semester S.D.	PSNS Year Mean	PSNS Year S.D.	Other Semester Mean	Other Semester S.D.	Other Year Mean	Other Year S.D.
Academic Interest Measure	18.6	7.7	17.9	6.8	16.5	8.0	18.5	6.8
Science Attitude Inventory	111.5	12.9	114.4	12.4	109.3	13.5	115.0	12.9
Test on Understanding Science	10.6	3.0	12.4	3.8	10.2	3.7	12.9	3.7
Science Process Inventory	69.6	8.0	73.8	6.4	69.3	9.7	73.0	7.1

TABLE 8

MULTIVARIATE AND UNIVARIATE F TESTS
COURSE X DURATION

	Effect		
	Course	Duration	Interaction
Multivariate F	1.51[a]	18.45[b]	1.20
Univariate F			
Academic Interest Measure Physical Science	1.19	6.22[c]	3.41[a]
Science Attitude Inventory	2.79[a]	13.75[b]	1.47
Test on Understanding Science	< 1	46.44[b]	1.73
Science Process Inventory	< 1	24.52[b]	< 1
d.f.	1/653	1/653	2/653

[a] $p < .10$

[b] $p < .05$

[c] $p < .01$

treatment. This is contrary to the main analysis of this study where students were assigned randomly to either the PSNS or Other course.

However, assuming that our statistical tests and logic agree, we do note a strong impact of duration on all four variables and must conclude that students learn more about the processes of science and have more positive attitudes when studying physical science for one year rather than for one semester. The results are consistent regardless of the course studied, PSNS or some other physical science course.

Part of the reason for urging caution on the part of this finding is related to a previous study which found no correlation between the time of treatment duration (within a 25 to 62 day limit) and achievement gains of physics students (Welch, 1968). Because the current results contradict the previous finding, further study is suggested.

Another problem in this finding related to the attitude changes (AIM and SAI) is that the overall change for both groups from pre to post-test was negative. That is, students' attitudes declined between pre and post-tests. This finding suggests that the decline is greater for one semester than for one year, a puzzling result considering there is twice as much of something students find objectionable. Perhaps the explanation lies in pre-climatic experience for those taking the course for only one semester, the full impact not being appreciated until one academic year has passed. In spite of the cautions expressed above, there does seem to be a significant duration effect that is not related to the type of physical science course studied. Achievement gains are significantly greater, and attitude decline is less for the longer treatment.

IV. Impressions From Site Visits

In this section, an entirely different approach is taken to provide information that might be useful to decision makers, the ultimate purpose of course evaluation. Earlier sections relied on standard research design techniques to obtain some measure of course outcomes. However, in this section some information will be summarized that was obtained through personal visits to seven of the 12 colleges participating in the study.

Because of the departure from usual research studies, it seems useful to provide some justification for including the judgment of an observer in this report. The criteria by which one judges the worth of an evaluation study is the usefulness of the information to a curriculum decision maker. In this study, I believed that my impressions from visiting schools and talking with students and professors would be useful to the course developers. They were in agreement. Hence, this section is a summary of my impressions from those visits.

There were several objectives to be achieved through the one or two day visits to the participating colleges. These are listed below:

1. Interview students in the PSNS and conventional courses to obtain their opinions about the respective physical science courses.

2. Interview professors participating in the experiment to determine the general success of the course and to identify any serious problems that might exist.

3. Obtain first hand impressions of the way in which physical science courses are taught in college to better understand the data being obtained by the various paper and pencil means.

4. Determine if the experimental course, PSNS, was being taught in such a way to qualify it as a valid evaluation of the course.

5. Establish personal contacts with the instructors participating in the experiment to insure the completion of the experiment.

6. Develop skill in judgment as a viable evaluation technique to be supported by data gathered in other ways.

A word of comment is in order about points 5 and 6. I was concerned that some of the participating schools might decide to drop out of the evaluation study, once they realized the magnitude of the task being requested of them. In order to reduce this possibility, part of the visit was designed as a public relations effort to insure the continued cooperation of the instructors. In addition, periodic phone calls were made to all 12 cooperating instructors to maintain contact with them throughout the study.

Objective 6 is not directly related to the current project, but grows out of a need to seek other valid means for curriculum evaluation. By testing the value of on-site visits, it was hoped that further advances in the state of the curriculum evaluation art would be made. In my opinion, because of the accomplishment of objectives 1 through 4, visitation to participating schools in a national evaluation effort such as this is highly desired.

Because of time limitations, I was able to visit seven of the 12 instructors participating in the evaluation study. The average time spent at each school was six hours. This is not a long time, but it did permit me to spend considerable time with each professor, interview 19 students and sit in on 14 physical science classes. It also provided an opportunity to form some subjective impressions that are summarized below.

The following observations are in my best judgment typical of the situation that occurs in college physical science offerings in general and in the PSNS course in particular.

1. Six of the seven instructors were very enthusiastic about the PSNS course and had plans to increase enrollments the following year. One person was uncertain about continuing the course because of his concern about the limited topics of the course. He believed that a content survey approach had greater value to students and was considering returning to a more conventional course.

2. The PSNS course seemed best received when it was taught in self-contained classroom style to 20 to 30 students in which laboratory work was part of the normal daily routine.

The PSNS course imposes its own structure that is not compatible with current physical science structure. It seems no more effective than traditional courses when forced into one or two large lectures per week with one scheduled two-hour lab section.

3. In every instance there was strong evidence that the PSNS course was in fact being taught as the experimental program.

4. The major problem with the new course is the difficulty in obtaining laboratory and demonstration materials from equipment suppliers.

A universal complaint during the evaluation year was the delays and problems the instructors encountered in ordering the new equipment. Hopefully, this problem will become less acute as the course gains wider acceptance.

5. The other problem most often voiced about PSNS is the amount of time required to prepare for a typical class.

Included here are problems of assembling new material, greater emphasis on laboratory apparatus, and the reorientation to teaching in a non-lecture manner. Again it seems reasonable to expect this problem will diminish as instructors become more familiar with the course.

6. There was little discernible difference in the reactions of students to the two courses.

Students in both courses were about equally supportive of their particular physical science experience. PSNS students talked about great interest in science, while the conventional students expressed satisfaction over knowing what was expected of them, and appreciating that a survey course was better suited for their intended occupation.

7. Instructors pick and choose a great deal in designing a physical science course. This is particularly true when the course is offered for one semester only. In the case of the PSNS course taught in one semester, a great deal of material must necessarily be left out.

8. In conventional physical science courses, the principal mode of operation is the lecture. Five of the seven conventional courses provided no laboratory experiences as part of the course.

Summary and Discussion

This concludes the presentation of the information gathered in the summative evaluation of the PSNS course. Within the restrictions of time and money, I have tried to select information that would be of use to curriculum decision makers. The eventual judgment of the study must be made by these decision makers based on whether such information is of value to them. Can a college professor make judgments as to whether or not he should adopt the PSNS course? Can the funding agency or its representative decide if their investment was worth the value received? Finally, do the course developers have some glimmer of hope that their six years of effort have produced a new physical science course that is capable of achieving their objectives? The information gathered in this study cannot provide yes or no answers to these questions, but only

contribute further to the storehouse of information available to each decision maker. If the information assists him to make a wiser decision, then this evaluation study has been successful. If such decisions are beyond reconsideration and the results of this study have no influence, then this evaluation is a failure. While educational research can subsist on the generation of knowledge alone, evaluation enjoys no such luxury. It is a practically oriented activity, and judgments of its success or failure must be made on practical grounds.

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References

Boercker, Fred. "Enrollments in Public High Schools by Type of Course and by Sex, 1964-65," Release of the National Center for Educational Statistics, 400 Maryland Avenue S.W., Washington, D.C., November 1966.

Cramer, Elliot M. and Bock, R. Darrell. "Multivariate Analysis," Review of Educational Research, Vol. 36, No. 5, 604-617, 1966.

Moore, Richard W. and Sutman, Frank X. "The Development, Field Test and Validation of an Inventory of Scientific Attitudes," Journal of Research in Science Teaching, Volume 7, Issue 2, 85-94, 1970.

Welch, Wayne W. and Bridgham, Robert G. "Physics Achievement Gains as a Function of Teaching Duration," School Science and Mathematics, 47:449-54, 1968.

Welch, Wayne W. Evaluation of the PSNS Course. Part I, Design and Implementation. (Mimeograph) University of Minnesota, Minneapolis, 1970.